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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Particulars of the proposed amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 20th February, 1918.

Any person, or persons, may give notice of opposition to the amendment by leaving Patents Form No. 18 at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

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Comptroller-General.

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Particulars of the proposed amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 20th February, 1918.

Any person, or persons, may give notice of opposition to the amendment by leaving Patents Form No. 18 at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

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India Office, London.
8th December, 1917. J 801

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MEN WANTED by large controlled firm in Manchester district. Must be quick and accurate at detail work. No person already on Government work will be engaged. Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4731. K 499

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THE THEORETICAL BASIS OF MODEL STRENGTH TESTS FOR AEROPLANE STRUCTURES.

By W. L. COWLEY, A.R.C.Sc., D.I.C., Wh.Sc. and H. LEVY, M.A., B.Sc., F.R.S.E., Members of the Scientific Staff of National Physical Laboratory.

THE importance of an accurate knowledge of stresses brought into being upon an aeroplane under various conditions of flight cannot be over estimated, in view of the manœuvres that the present war machine must be able to execute with safety. The analytical treatment of this question of stresses in aeroplane structures is unfortunately extremely complicated, both on account of our present lack of mathematical knowledge, and of the imperfectly known factors affecting the strength. If justifiable and at the same time sufficiently simplifying assumptions could be made, we might proceed with considerable rapidity to a solution, but unfortunately it is only as a result of careful experimental work that valid assumptions of this nature could be furnished.

As a simplification of the question, it is generally assumed in practice, that the problem of the strength of the various parts of an aeroplane structure is self-contained and independent of the existence of neighbouring parts. An attempt for example is made to treat the wing system as an isolated structure, or the body and fuselage, the tail system or the undercarriage. But it cannot be supposed that this assumption even if it should—as it generally does not—lead to a complete mathematical solution is in any sense satisfactory, for it is clear that the mere fact that in the complete aeroplane these parts are not isolated involves an end condition, in general indeterminate, to be applied to the isolated portion. For example, the problem of the strength of a fuselage under the torsional effect of the force on the rudder might admit of an approximate solution even if the redundancies which occur were known, provided the effect of the body upon it in the region of juncture could be assumed. This itself would obviously depend upon the degree of rigidity of the framework in the neighbourhood of the gap-struts, and it would thus appear that the isolation of a particular part, and its treatment by rigorous mathematical methods is at most a very rough approximation to the true problem. Even in those cases where this isolation may be affected with any degree of justification, as for example, in the case of the wings, a still further simplifying assumption requires to be introduced to reduce the remaining complications. In the case referred to, it is customary to treat the effects of the normal and of the longitudinal forces on the wings separately, on the assumption that the effects can be added algebraically. Whether or not this method of treatment is legitimate can only be determined by experiment, but at any rate, it is already recognised that in the case of a staggered biplane the results are far from the truth, and intelligent designers are compelled to face the question whether the gain in aerodynamic efficiency derived from the stagger is not counterbalanced by the uncertainty of the conclusions from stress calculations. Frequently it has happened, in fact, that unknown factors for which allowance could not be made, because of our ignorance of their magnitude, have been such as to reverse completely, the conclusions as regards strength. For example, wing structures which on calculation have indicated weakness have been found on final trial to furnish a much better performance than that anticipated, on account of the effect of such unknown factors as the fabric, ribs, &c. Although in this case the errors have occured on the safe side they are just as likely to be on the other side, and involve weakness. A continuance of the present method of blind groping is clearly wasteful and futile.

It appears then, that the failure of analysis to treat this problem in any satisfactory manner demands the pursuit of some line of experimental investigation for confirmation of the analysis at least, if not for more direct and positive research into the question. If the basis for such experimental work could be securely laid, it would be possible to produce results both of empirical value and of the nature of the simplifying assumptions required for the mathematical treatment. To some extent the ground has already been broken on this question by tests to destruction on full scale machines. The part to be tested is loaded with sand bags according to distributions previously determined, until collapse occurs. Apart from the expense and cumbersome nature of this test it is clear that serious limitations are imposed upon its application to determine the effects of apparently unimportant parts, and various degrees of complexity of loading. No such experimental difficulties arise, however, if it should be possible to conduct the test upon a model, under which circumstances complete command can normally be obtained over the experimental conditions.

If the basis of the methods of transition from results on model tests, to full scale, could once be made secure it is evident that an immense advance could be made and tests executed with rapidity, thoroughness and relative cheapness. This point scarcely requires emphasis.

It is proposed to show that the theoretical basis of the whole method may be developed in quite a rigorous yet simple manner by an application of the principle of homogeneity of dimensions to the type of problem under discussion.

When a homogeneous prismatic strut of length l pin-jointed at the ends is subjected to axial end thrusts, then up to a load given by

$$F = \pi^2 \frac{E I}{l^2}$$

the undeflected position is one of stable equilibrium provided the ultimate stress is not exceeded. Beyond this so called Euler's critical load, the straight position is one of unstable equilibrium. If the strut be deflected, as long as the load is maintained the axis will continually undergo change in shape until it ultimately takes up a form of elastica. During this process the yield point of the material of which the structure is composed may be exceeded and the material may rupture. The strut may thus be supposed to fail for two possible reasons, on the one hand because its shape has been permanently changed from the straight normal position owing to the instability of that position, and on the other hand because the actual material has failed to withstand the stresses originated. This conception is of course not limited to such a simple structure as a strut, for it may be seen that in general a framework of any kind may fail for either of these two reasons. In the first place the geometrical configuration may be such that when the structure is subjected to a particular type of loading a small disturbance may involve a continuous change in shape until a finite deviation or deflection is produced. This presupposes that the geometrical shape is considered maintained as long as alterations in outline are at most of the same order as those of the disturbance, assumed small. In the second place, irrespective of any alteration in the geometrical shape of the structure, if the stresses brought into being immediately subsequent to the loading are as great as, or greater than the ultimate stress the material can sustain so that the yield point is reached, the structure will collapse by direct rupture of the weakest member. Even if no external loading be applied, but the structure is under forces due only to its own weight—in a sense, of course, external loading—it can be shown that a limit exists to the dimensions of a geometrically similar structure made of the same material, so that if this limit be exceeded stresses will be called into existence so great as to involve rupture. It is proposed to investigate what information may be furnished regarding these two types of failure, rupture and instability, by an application of the dynamical laws through the medium of the dimensional theory.

Consider the case of a structure of the type of an aeroplane framework for example, where it is supposed that the assumptions made in the ordinary beam theory apply to every part. Let the length of one part, say a bay, be given by l, the area of a particular section by A, moment of inertia I, and the elasticify and density of the material of which it is composed E and ρ, respectively. Given these quantities for this one portion, it will be assumed that the shape and geometry of the structure involve an exact specification of how to derive the corresponding quantities for the remaining portions. Let the external load be F, applied in some given manner specified by the geometry, and suppose this is sufficient to produce a stress just greater than the yield stress f in the material of the weakest member. F can only depend apart from the geometry and manner of application upon the quantities enumerated above, defining the properties of the material. These are as follows:—

Physical quantity.	Symbol.	Dimensions.
Young's Modulus ...	E	... M/L T²
Area	A	... L²
Moment of Inertia ...	I	... L⁴
Length	l	... L
Density	ρ	... M/L³
Yielding stress ...	f	... M/L T²
Gravity	g	... L/T²
Load	F	... M L/T²

Since F, the load which will cause collapse by rupture of the material, must involve all these quantities grouped together in such a manner as to make the dimensions of the product identical with those of F we may write

$$F \propto E^x A^y I^z l^p \rho^s f^r g^t,$$

The dimensions of this are clearly

$$M^{s+t+r} L^{-x+2y+4z+p-3q-r+t} T^{-2s-2r-2t} = \frac{M L}{T^2}.$$

Equating powers of M, L, and T,

$$s + t + r = 1,$$
$$-x + 2y + 4z + p - 3q - r + t = 1,$$
$$s + r + t = 1,$$

$$\therefore F \propto E l^2 \left(\frac{f}{E}\right)^r \left(\frac{A}{l^2}\right)^y \left(\frac{g l \rho}{E}\right)^s \left(\frac{I}{l^4}\right)^z.$$

It will be more convenient to write this in the form

$$F \propto \frac{E I}{l^2} \left(\frac{f}{E}\right)^r + s \left(\frac{A}{l^2}\right)^y + s \left(\frac{W}{f A}\right)^s \left(\frac{I}{l^4}\right)^z - 1,$$

where instead of $g l^3 \rho$ its equivalent W, the weight of the portion of the structure considered, is taken.

It is evident that every term in the expression for F must take the form given above, but so far no restriction has been imposed on the values of the quantities r, s, y and z. Under these conditions F could be represented as the sum of a series of terms in which f/E, A/l^2, $W/f A$, I/l^4 could appear to any power whatsoever, but in each such term $E I/l^2$ would be a factor. This is equivalent to the statement that

$$F = \frac{E I}{l^2} \psi \left(\frac{f}{E}, \frac{A}{l^2}, \frac{W}{f A}, \frac{I}{l^4}\right),$$

where ψ for the moment is an arbitrary function. Writing

$$\phi^2 = F l^2 / E I \quad . \quad . \quad . \quad (1)$$

so that this quantity may be considered as a non-dimensional critical loading coefficient, it follows finally that

$$\phi^2 = \psi \left(\frac{f}{E}, \frac{A}{l^2}, \frac{W}{f A}, \frac{I}{l^4}\right) \quad . \quad . \quad . \quad (2)$$

It is clear from the definition of ϕ, that for a given structure where l, E, and I are known ϕ is uniquely determined when F, the breaking load is found, so that the discussion of collapse by rupture may equally well be centred round ϕ. Let it be clearly understood that the exact form of the function ψ in (2) depends only on the geometry of the structure, including the manner of loading and the law of distribution of material.

Similarity of Structures.—Out of the general class of framework embraced in this discussion so far let there be selected a series of which all members are identical with respect to external shape, differing only in magnitude. This implies that A the area of cross section of any selected part is proportional to l^2 and I to l^4. For this series, therefore, A/l^2 and I/l^4 are constants depending only on the geometry, and accordingly expression (2) now takes the simplified form

$$\phi^2 = \psi_1 \left(\frac{f}{E}, \frac{W}{f A}\right) \quad . \quad . \quad . \quad (3)$$

It is not difficult to give an interpretation to the two non-dimensional quantities f/E and $W/f A$. The former being the ratio of the yielding stress to Young's modulus may be taken as the strain at the yield point, on the assumption that Hooke's Law applies rigorously over the whole range. In the same way $W/f A$ is the ratio of the weight of a particular member, say the weakest, to the maximum tensile or compressive force, as the case may be, which that

member is capable of withstanding without yielding assuming that the section A is taken at the position of collapse.

As far as a discussion of the breaking load coefficient ϕ^2 is concerned, it is evident that if a series of geometrically similar structures be selected two distinct variables, and two only, functions of the material affect the question. These are the strain at the yield point for the weakest member, the ratio of the weight of that member to the maximum tensile or compressive force it can withstand at the point of yield. It is equally clear, however, that the so-called geometrical restrictions determining the distribution of the constants of the materials in a composite structure are not absolutely vital to the above discussion, so that violations of the laws determining the selection of the material from member to member would not necessarily vitiate the conclusions arrived at here. For example, one would not be rigorously entitled to vary l, A and E in certain members, since such a change would clearly upset the geometrical similarity of shape and the distribution of force with the possible result that the previously weakest member might now not remain such. No such trouble, however, could arise if the selection of the materials was made without changing these factors, but allowing a variation in f the yielding stress so long as the previously weakest member always remains so in the series. This is equivalent to an increased latitude in the scope of selection of material.

Generally in experimenting with a model of this nature it is convenient, of course, to have corresponding parts in the model and the full-scale structure composed of identical materials. If for example, the frame of an aeroplane were under discussion, wires in the model would be composed of the same metal as those in the original, corresponding struts, spars, ribs, &c., of the same wood.

Since the quantities f, E, l, ρ, &c., in the expressions for ϕ^2 all refer ultimately to the same part of the model, to ensure geometrical similarity in the widest sense it follows that the assumption that f/E is a constant is one which is obvious experimentally. Under these circumstances also W/fA, as can easily be verified becomes proportional to the linear dimension l. The breaking load coefficient ϕ^2, therefore, when the weight of the structure contributes towards rupture is purely a function of l,

$$\phi^2 = \phi_1(l),$$

and the form of the function is determined only by the shape of the various parts, the geometry of the loading and the so-called geometry of the material.

This expression for ϕ^2 may likewise be supposed solved for l in terms of ϕ. For every external load coefficient this equation then determines the size of the structure corresponding to failure. When there is no external load and failure is due to weight alone $\phi = 0$ and the result previously anticipated is seen to hold.

Structures of Negligible Weight.—When the material is not sufficiently heavy to involve the weight of the structure appreciably as a factor in causing collapse the term W/fA may be omitted in equation (3) and the expression for ϕ^2 takes the relatively simple form

$$\phi^2 = \phi_2\left(\frac{f}{E}\right).$$

Let us imagine that the weakest member is replaced by another of the same geometrical shape and size but with a different value of f/E, though not so different as to prevent its remaining the weakest member, then a test on each one of these models will give a particular value of ϕ^2, breaking load coefficient, and these when plotted against f/E will give a "characteristic curve" for the structure of the given geometry. For geometrically similar structures of which the corresponding parts are made of the same material, so that f/E is constant, the critical load coefficient becomes an absolute constant for the series depending for its value purely on the shape. It follows that a simple test to destruction on a model will suffice under these conditions to determine the breaking load coefficient ϕ^2, and therefore the breaking load F for any other member of the series.

Failure Due to Instability.—It is assumed in this section that the failure is not necessarily accompanied by collapse or rupture in the material but is due merely to permanent deformation of the configuration of the structure. It follows that in the expression for the critical load, the yield stress does not enter although all the other terms A, l, E, I, ρ, g may do so. Using ϕ^2 as a critical load coefficient defined by $F l^2/E I = \phi^2$ then

$$\phi^2 = \psi_1\left(\frac{A}{l^2}, \frac{W}{EA}, \frac{I}{l^4}\right) \quad . \quad . \quad (4)$$

obtained by the same method as in the previous section.

On the understanding that the structures in the series are all geometrically similar as regards external shape without reference to material composing them, then A/l^2 and I/l^4 are constants for the series and

$$\phi^2 = \psi_2\left(\frac{W}{EA}\right) \quad . \quad . \quad . \quad . \quad (5)$$

where W/EA is the ratio of the weight of a member to the tensile or compressive force required to produce unit strain at some particular section of that member.

If corresponding members of the series are made of the same material then W/EA is easily seen to be proportional to l, from structure to structure and as before the critical loading coefficient,

$$\phi^2 = \psi_3(l) \quad . \quad . \quad . \quad . \quad (6)$$

depends on the size only.

When the weight of the structure is negligible as far as its effect in contributing to failure is concerned, the whole instability arising from the external loading, then ϕ^2 is a constant for a series of structures of identical form irrespective of the material of which it is composed, and a test to destruction on one model suffices for the series.

It has been found that the critical loading for a uniform prismatic strut of negligible weight under end thrusts and pin-jointed at the ends is given by $F = \pi^2 \frac{EI}{l^2}$, where l = length of strut, I the least moment of inertia, and E = Young's modulus, so that ϕ for this structure is π. For a strut under the same conditions but with fixed ends $\phi = 2\pi$.

In certain cases of simple shapes of structures, it is obvious that the function ϕ^2 may be derived by calculation as for example in the case of the prismatic beam supported either on "pin-joints" or clamped supports, but for more complicated problems where the calculation is too abstruse a number of points on the characteristic curve may be derived by a series of tests to destruction on models.

In the special cases where ϕ is a constant for the series a single test on one model is clearly sufficient. This as has been shown, applies with equal force where the collapse is due either to instability or failure of the material.

The basis of the experimental method thus having been made secure, no scale effect difficulty of the type normally arising in aerodynamic work being present, it should now be possible to proceed to a direct accurate test of failure and its causes under various circumstances. As usual there are of course both advantages and disadvantages to be faced. A model of an aeroplane or a special part sufficiently accurate for the present purpose may be constructed at comparatively little cost. All the numerous details of contour and finish that are normally necessary in the production of such a model for ordinary aerodynamic purposes now find no place here. The question as to whether exceptional care or otherwise would require to be exercised with any special portion, as for example the junctions between the fuselage and the remainder of the machine, the junction of the wires and of the spars and ribs, &c., could of course easily be settled experimentally by testing for consistency of results.

A much more serious question, however, is that involved in the possible invalidity of the foregoing analysis should Hooke's Law fail to be obeyed—a real difficulty in the case of wood of which most of the members are composed—but exactly the same trouble would arise in a mathematical investigation of the stresses brought into play. In all such cases Hooke's Law is assumed to hold.

Two further points merely require to be mentioned. There is no mathematical machinery at our disposal for determining accurately the dynamic effect of a variable load such as occurs for example when an aeroplane is executing rapid manœuvres of particular types, or when the controls are brought sharply into operation. Essentially this is of the nature of an impulsive loading and the ordinary convention that it suffices to consider it as a live load and thus to double the safety factor cannot be regarded as quite satisfactory. Physically the problems are quite distinct. Secondly the question of the effect of vibration of and upon the structure has received scant attention. Model experimental work of the type indicated, clearly furnishes an extremely convenient method for approaching these problems.

THE STATE OF CHINA FROM AN ENGINEERING POINT OF VIEW.

In a previous article the railway and road situation in China has been dealt with, and it is now proposed to summarise those factors which militate against engineering progress, and to give some account of the present condition of public works in the country.

Of the factors opposing progress the most adverse is undoubtedly the colossal ignorance of the people, the large majority of whom are absolutely illiterate and lead a hopeless animal-like life whose only interest is the long fight against starvation and taxes. This ignorance, coupled with religious superstition, makes the people easily influenced by unscrupulous officials or priests, who thus control a very powerful weapon which can be used against any project to which they are unfriendly A short summary of Chinese superstitions will be necessary and it should be stated that these superstitions are very deep rooted, that any project undertaken by foreigners needs strong Government backing, and that no greater mistake can be made than to offend local officials or to attempt to interfere with purely native matters. The Chinaman is a past-master at the art of obstruction.

The national religion may be said to be Taoism, or Buddhism, as both have become so debased that they are hardly distinguishable, the myriad gods of both being interchangeable. The temples of both persuasions are equally ruinous and filthy, and their priests as a rule the lowest of the low. Except at festival times they are hardly ever visited. Both religions have degenerated into spasmodic efforts at the propitiation of thousands of gods mostly evil in influence, so working on the feelings of people as ignorant as the Chinese is a very easy matter. Further, the rock on which China's moral code is built is respect for parents and the aged coupled with ancestor worship. From this it is easy to understand the inviolable sacredness of all burial places. This would have little effect on engineering progress were it not for the fact that the Chinese only bury the dead in places were the "fengshui" is good and not in large cemeteries "Fengshui" has been described as terrestrial astrology, and may be said to be the potentiality of a place for good or evil effect on the fortunes of the people in the neighbourhood. Thus, as each family buries its dead on the family land, graveyards are dotted indiscriminately all over the country. The places of good fengshui are determined by astrologers who make a living out of such consultations. In many cases the burial is only temporary, for if ill-luck should dog the fortunes of the family astrologers are called in again and the fengshui of the burial place found to be at fault. Disturbance of the ground in the neighbourhood of any burial-place ruins its "fengshui," so that all families with graveyards within a certain distance of a railway have to be compensated and the bodies removed at the expense of the railway. In some cases powerful families have been able to secure the deviation of the line in order to avoid this indignity. "Fengshui," though it is a hindrance and an expense to railway construction, would not matter if hills, streams and rivers did not have this property for good effect which may be upset by disturbance of the ground. This touches the large question of mining, and places a powerful weapon in the hands of the unscrupulous. Thus, if a local official has not been sufficiently pro-

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(*For Description, see Page* 221.)

Fig. 26.

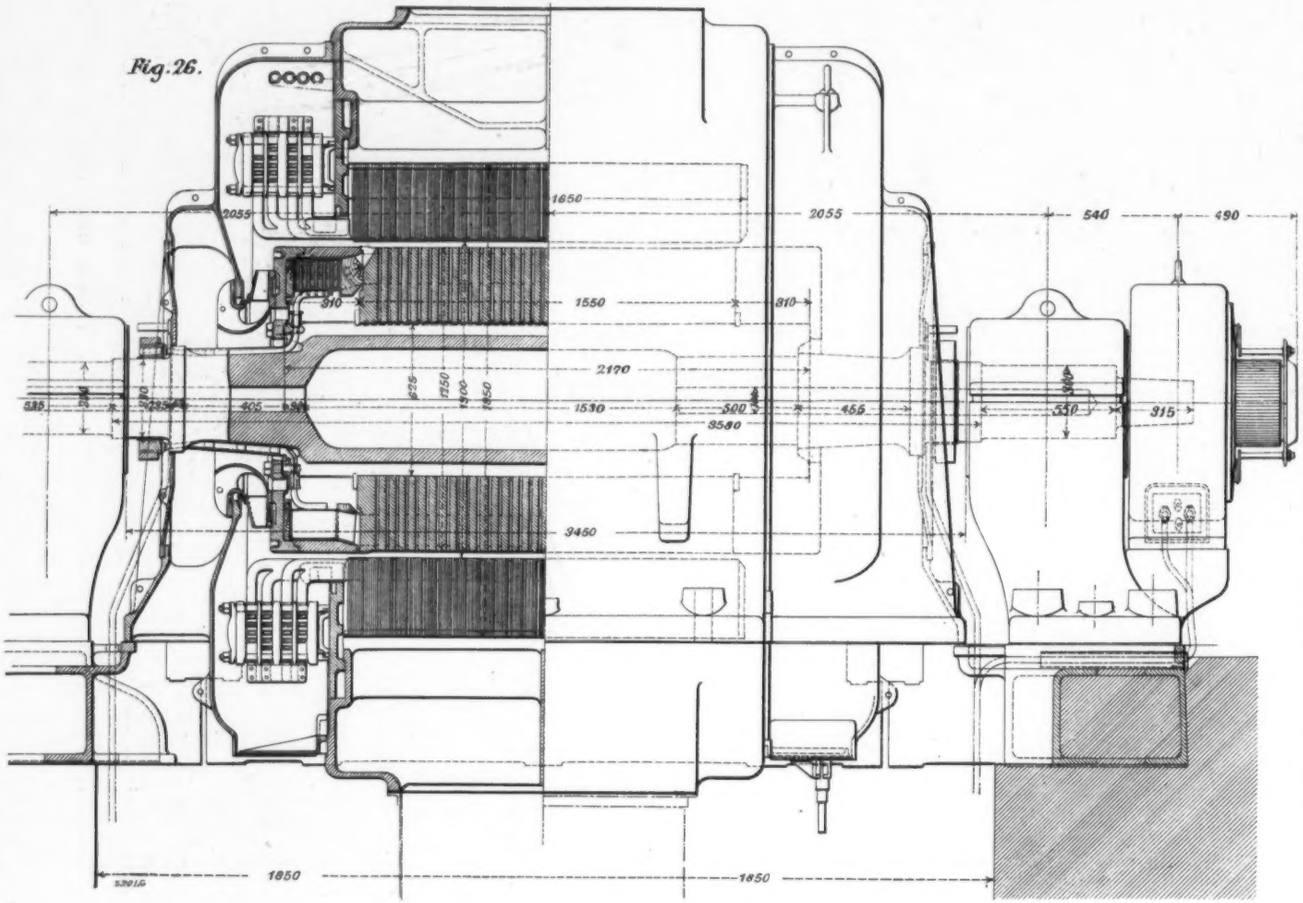
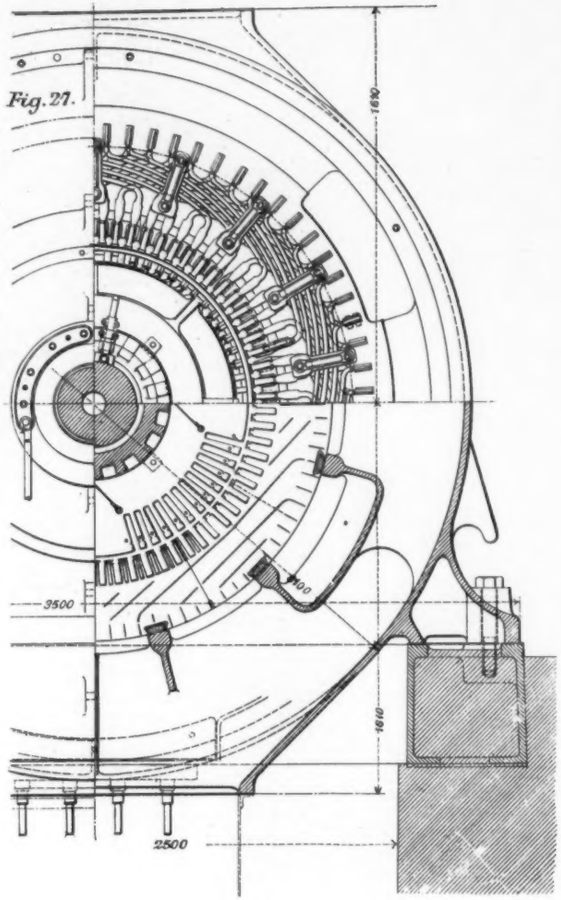


Fig. 27.



FIGS. 26 AND 27. 10,000-KILOWATT THREE-PHASE GENERATOR.

Fig. 28.

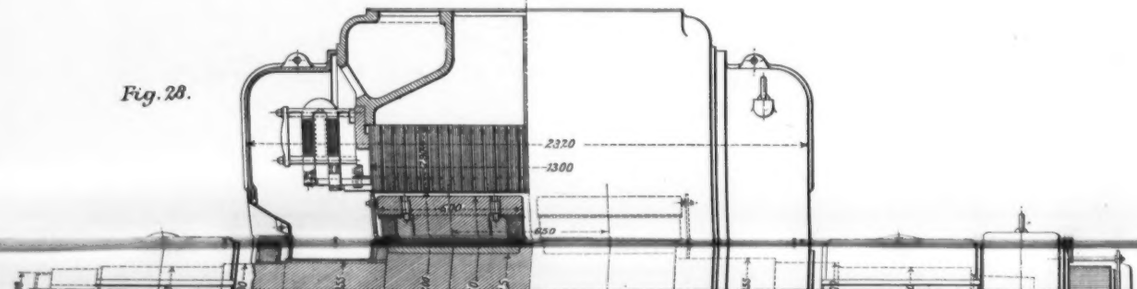
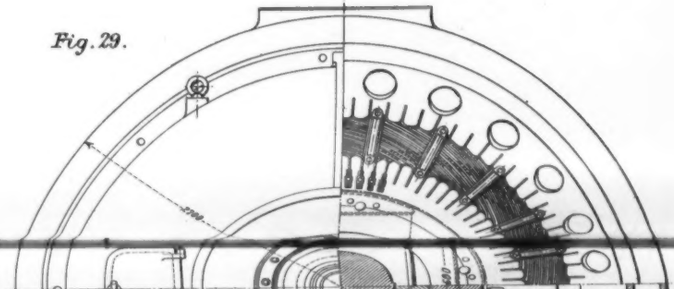
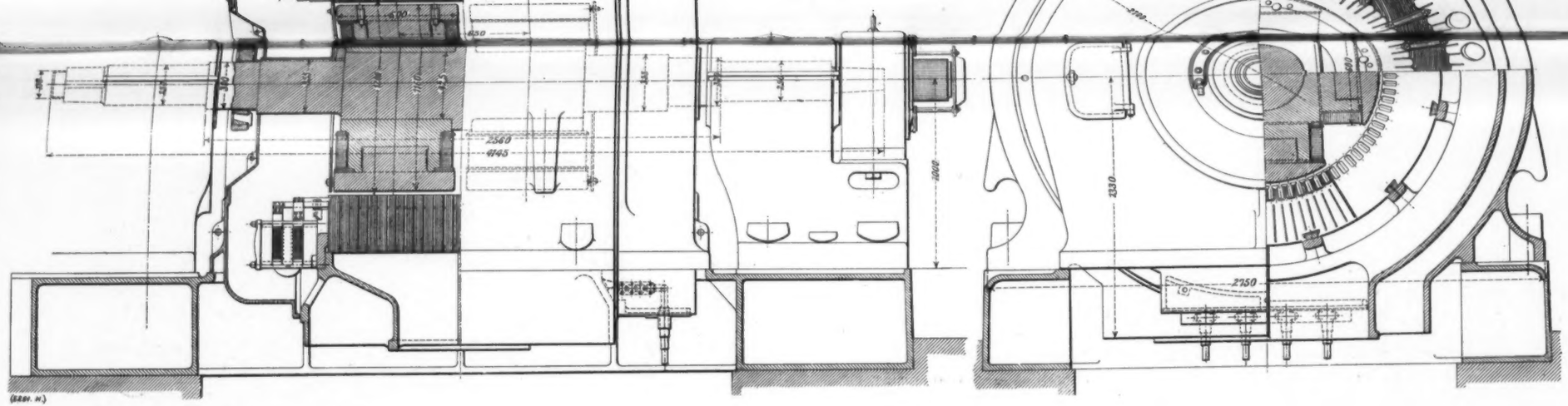
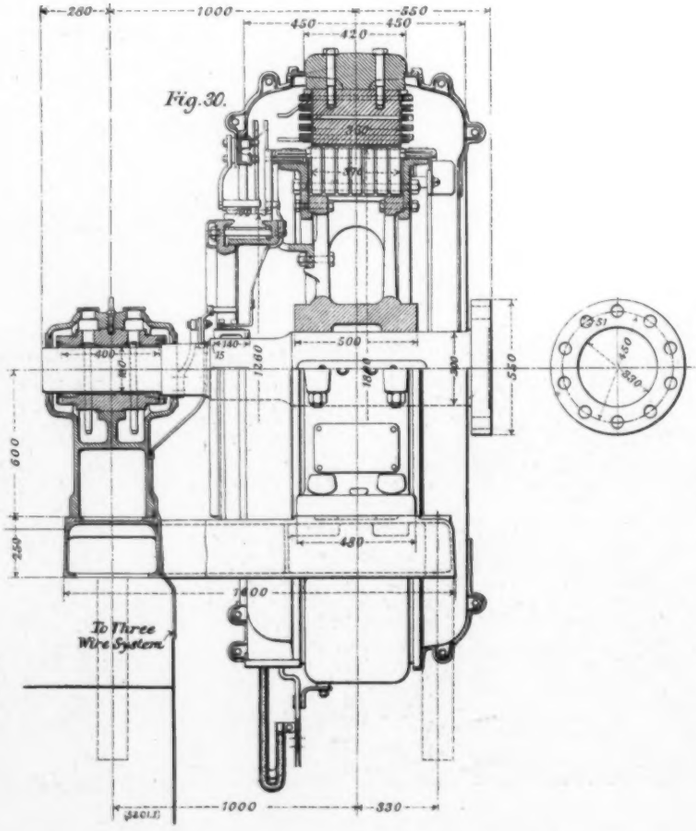


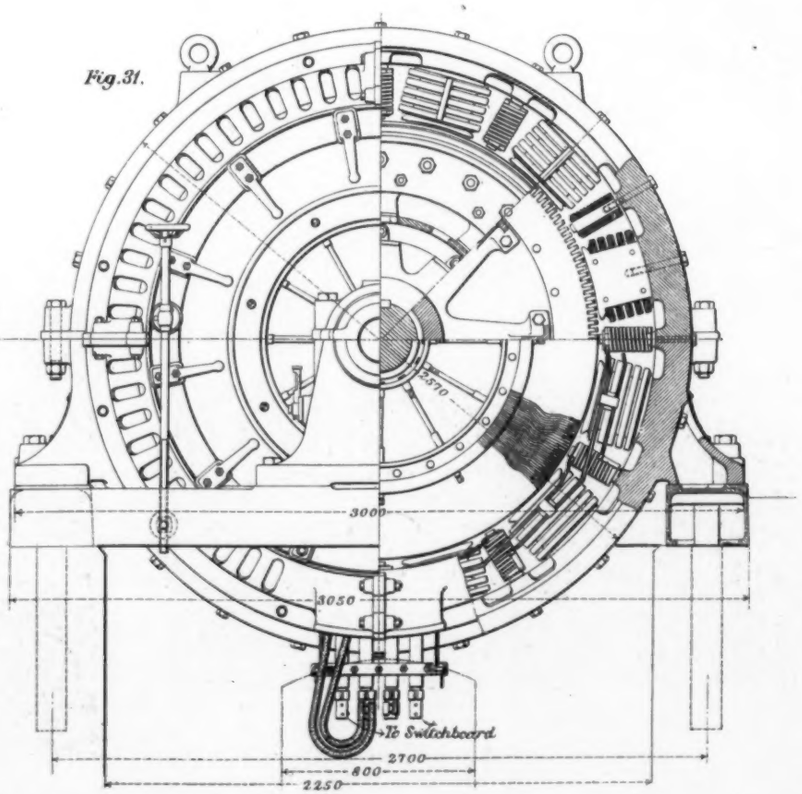
Fig. 29.





FIGS. 28 AND 29. 5000-KILOWATT THREE-PHASE GENERATOR.





FIGS. 30 AND 31. 500-KILOWATT DIRECT-CURRENT GENERATOR AT THE TRES SARGENTOS SUB-STATION.

pitiated, it is very easy for him to suggest to the priest that quarrying a certain hill or diverting a stream will ruin the "fengshui" of the district, and that drought and other evils will follow.

Superstitions like the above account for many of the architectural features of the country. Thus two-storied houses are the exception, the entrance to a house is always from the side, a blank wall being built opposite the entrance, no roof ridge is ever straight, high chimneys are taboo, and telegraph wires over a house the worst of bad luck. Many of the very beautiful pagodas were also put up in order to better local conditions from this point of view. Such beliefs are at the root of much of the local opposition to railway and mining projects, and have played a part in opposing the introduction of anything of a progressive nature.

Unfortunately it cannot be said that the new education schemes have done much in eradicating these beliefs. Education, such as it is, is practically confined to the townsfolk, the coolie and farming class having neither the time nor opportunity, living as they do in the majority of cases with such a narrow margin between life and death.

In China, education is represented by 11 universities, 31 technical schools and colleges, and 55,000 primary schools. The fees are not extortionate, thus 7*d.* per month can be charged to those able to pay in the primary schools, and 2*s.* in the technical schools; 6*s.* in the universities is the usual monthly charge for tuition. This is not much provision for about 400,000,000 people. The quality of the education given is not of a very high order, in the primary schools, memorising by parrot-like repetition in chorus being the usual method, while the courses provided in the technical schools and colleges do not take the student so far as in similar institutions in Europe.

It can, therefore, be seen that up to the present, while the Government has done something for the townsfolk, little or nothing has been done to ameliorate the condition of the coolie class. As has been shown, the material condition of this class is too poor to begin education yet, but much might be done in an educational way by improved communications, more especially by the repair and reconstruction of the road system of the country. The roads of China were once properly maintained, but were allowed to fall into disuse by the Manchus in order to strengthen their hold on the country and thus avoid all concerted action among the conquered Chinese. Better roads would tend to stimulate travel, the broadening effect of which would do great good, as it would tend towards the abolition of many trade-hampering restrictions, promote larger ideas, and perhaps do something in the direction of some sort of agreement between the north and the south, whose aims appear to be about as irreconcilable as those of Ulster, and the rest of Ireland. At present, partly owing to the hampering effect on intercourse of many dialects, partly to bad communications, the average coolie can see no interests but those of his own village, has no critical faculty, and blindly believes what he is told, and will, if necessary, fight for those beliefs. There is no national or even provincial feeling, no cohesion, and no patriotism of a large kind, the vast majority of the people neither knowing nor caring who rules in Peking. All the recent changes and disturbances have been effected by parties having the very shadowest claim to represent national feeling, the bulk of the people carrying on business as usual, and only concerned as to whether the fighting and devastation, all of which has been on quite a small scale, will pass by their own district. The Government might also do vast good by conserving and regulating China's many troublesome rivers, and by repairing many of the great irrigation dykes and barrages long since fallen into disuse. Among such schemes might be mentioned the improvement of the Grand Canal and the conservation of the Huai River, projects which mean life and death to many thousands of people. A preliminary to any project however urgent, is the total suppression of brigandage, which has been on the increase ever since the Revolution of 1911, in itself an indication of the bad state of the country, for only desperate straits makes brigandage a popular profession in China. Another very necessary reform is one affecting the holding of Government posts as at present the length of tenure is so uncertain as to deprive the holder of all interest in his work, and make him consider everything from the point of view of his own pocket. It is this spirit, fostered by the Government, which has accounted for the neglect in the past of the public works of the country.

With regard to the present condition of these works in China, with the single exception of the railways, all are equally neglected (those of a defensive nature rightly so), and only serve as a monument to a very wonderful people. The majority of these great works were of a defensive nature such as the Great Wall of China, built B.C. 249–206. This wall, about 1,500 miles long, originally was about 30 ft. high and 12 ft. wide on the top, with salients every 400 ft. It is, of course, loopholed, and has a 6-ft. high curtain wall on the top. The wall consists of a facing of brick or stone, according to locality, about 2 ft. thick, with an earth backing. It was built by slave labour. In the neighbourhood of towns and villages all the facing has been carried off for building purposes, only the earth core remaining.

With the exception of Tientsin, whose walls were destroyed in 1900, practically all the cities of China are walled. The construction of these walls is similar to that of the Great Wall, but bricks are usually used for facing, a string of large blocks of ashlar being usually introduced in the lower courses. In many cases the foundations have proved too weak, and huge settlements have occurred, but the universal use of lime and mud concrete in all foundations has in the majority of cases prevented this. This concrete is apparently peculiar to China, and is a mixture of about six of dry earth with one of unslaked lime spread in thin layers and rammed hard. It is extremely efficient for the foundations of buildings on new banks and is universally used on all the railways in the country. Very few piled foundations are come across, but small round piles not exceeding 4 in. in diameter have been met with in the foundations of one city wall. These piles were above water-level, but had been charred, and were perfectly sound. There is also evidence that the Chinese used piles in the foundations of most bridges where water difficulties occurred.

As a rule the walls of the cities face the four points of the compass, and it will be found that most buildings are built facing south. There are usually four main gates, one in the middle of each wall. These gates have a large courtyard in front surrounded by a wall similar to the main wall and with another gate, which is always at right angles to the main gate. Each corner of the walls has flanking towers. Moats are unusual, but there are instances. In many cases the city walls are still kept in some sort of repair.

The golden age for public works was the Han dynasty, B.C. 206 to A.D. 221, when there was great activity in the construction of roads, canals and irrigation works. The roads for the most part are unmetalled, but raised slightly for drainage purposes by borrowing from side ditches, in a few places they are paved with large blocks of dressed stone, about 3 ft. by 1 ft. by 1 ft. thick, which make a most uneven and abominably slippery surface. The only macadam roads in the country are those in the foreign settlements, and in the native cities of Nanking, Hankow, Tientsin, Peking and Newchang. The road bridges are generally of the arch type, with spans running as high as 60 ft. These are generally of dressed stone, the stones of the arch being too thin and long by modern standards, but in the majority of cases the arches have proved strong enough for the traffic they were built for. In the province of Yunnan light suspension bridges with spans as great as 240 ft., are quite common. They are without any stiffening girders, and will only take mule and passenger traffic, the only form of traffic met with on the footpath roads of this province. Smaller openings up to 15 ft. span are generally bridged by a series of flat stone slabs or by tree trunks on which a flooring of millet stalk and mud is laid. In many cases road bridges have entirely disappeared, most probably from foundation failure, as most of them seem to be only built to take the dry weather flow. Bricks have been very extensively used for arch rings in city gateways and fort entrances, but the workmanship is not good. The brick used is hand-made, varying in size from 1 ft. 6 in. by 10 in. by 6 in., to about the size of the standard 9-in. brick. It is extremely porous, and often insufficiently burnt, and therefore quickly destroyed by frost in damp situations. Chinese notions of bend both in brickwork and masonry are very rudimentary.

China's most notable public work after the Great Wall is of course the Grand Canal. This canal, 850 miles long, was begun in 600 B.C., the southern section between Chinkiang, on the Yangtse River, and Hangchow, being built from A.D. 607 to 617, while the northern section, from the Yellow River to Tientsin, was built from A.D. 1280 to 1283. It was once the great highway between the north and south, but lack of maintenance of the weirs and sluices which controlled the water supply to the canal, have led to silting up and entire disuse in some parts, while insufficient conservation of the rivers supplying the canal has lead to most disastrous floods in districts west of the canal, more particularly in the valley of the Huai River. The canal, as built, had a channel of about 200 ft. and depth to take the largest junks, about 8 ft. In the districts between the canal and the sea, in the provinces of Chekiang and Kiangsu, there is a wonderful system of canals, which still make modern methods of transport needless in these districts.

Of works dealing with water supply and sanitation there are none in existence, and it is questionable if they ever did exist or were felt the need of. The Chinese drink well water or river water without a thought as to its possible pollution. That it is polluted goes without saying when it is understood that no cities in the country are sewered and that the riverside cities always have an enormous boat population at their gates. Burial grounds are very often quite close to the wells, which are without exception dry-lined and as shallow as possible. There is very little doubt that, though the Chinaman suffers from typhoid and other water-borne diseases, he is not attacked to the same extent as the European, most probably because of the habit of drinking most liquids hot in the form of tea, &c.

Water works have been established or are under construction in 17 cities, but none, not even the foreign settlements have attempted sewerage systems. In every case the source of water supply has been a river, filters being used, but all careful householders boil and filter all water for drinking purposes.

With regard to sewage disposal, a few of the large hotels in Shanghai and Tientsin have septic tanks, but otherwise a sort of pail system is universal throughout the country. In Shanghai and other settlements under foreign control where sanitary departments exist, the removal is carried out at night, but in most Chinese cities this objectionable business is carried out in broad daylight in the main streets. The night soil is sold, and used for fertilising purposes. Rubbish, offal and cinders from the houses are usually thrown into the street, where the dogs and pigs, the scavengers of China, make short work of anything in the remotest degree edible. No street cleaning is done in most cities.

(To be continued.)

ELECTRIC POWER SUPPLY AT BUENOS AIRES.

(Continued from page 143.)

THE generators have all been supplied by Messrs. Brown, Boveri and Co. There are some differences of detail in the construction of the 5,000-kw. and the 10,000-kw. machines which will be apparent on reference to Figs. 26 and 27, Plate XIX, which represent the larger machine, and Figs. 28 and 29, which refer to the 5,000-kw. machines originally installed. The larger machine has the cylindrical type of rotor introduced by Mr. C. E. L. Brown shortly after his firm began the construction of steam turbine machinery. The rotor is built up of plates shrunk on the shaft which, owing to the large diameter of the rotor, can be made very rigid. Air spaces are provided between successive plates

ELECTRIC POWER SUPPLY AT BUENOS AIRES; THE SWITCHBOARD.

CONSTRUCTED BY MESSRS. BROWN, BOVERI AND CO., ENGINEERS, BADEN, SWITZERLAND.

Fig. 32.

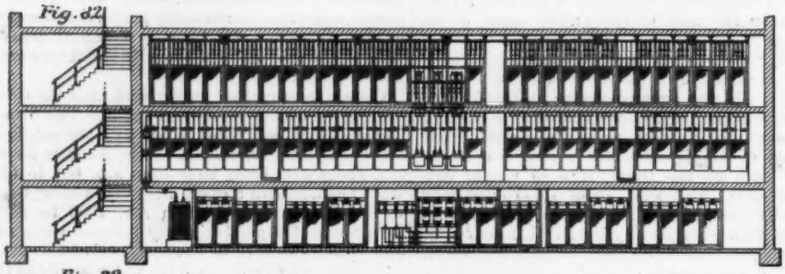


Fig. 33.

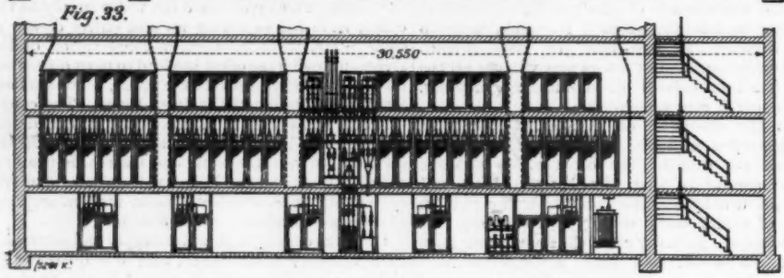
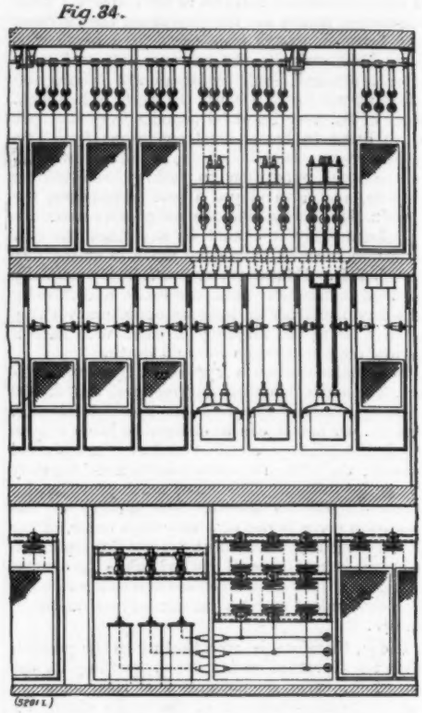


Fig. 34.



and permit of a very effective ventilation of the rotor when running. The winding is composed of flat copper bars insulated with mica and press-span. The conductors are held in position by long compound keys of steel and drawn brass. The ends of the windings are covered with caps of forged nickel steel, which afford ample security against the severe centrifugal forces to which they are subjected. The metal used for the stator stampings is specially selected to reduce to a minimum the losses due to the rapid alternations of the magnetic flux. These stampings are insulated from each other by silk paper, and numerous ventilation ducts are provided. The winding is in two layers, which makes it easier to secure perfect symmetry of the field. The "outboard" connections for these windings are very securely supported, and insulated and are thoroughly well ventilated.

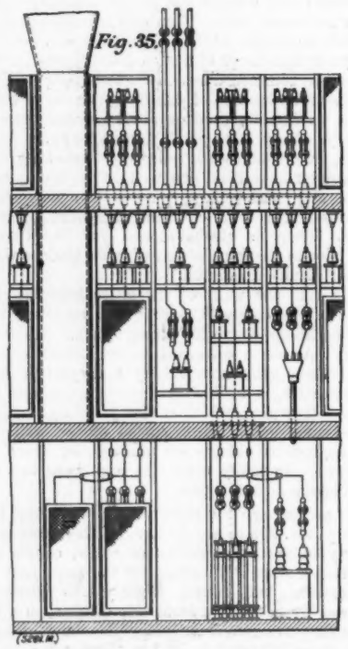
The smaller machine illustrated in Figs. 28 and 29, is, in general particulars, similar to the foregoing, but has, as shown, a rotor of the salient-pole type. There are, it will be seen, eight of these poles. The section is circular and the pole cap is screwed on. The winding consists of a flat copper bar insulated by press-span and wound in place by a special tool. The pole pieces are shaped so that the current curve is practically of pure sine form. In this type of machine the ventilation is secured by the rotation of the rotor itself without the assistance of the fans provided at each end of the rotor of the larger alternator.

We illustrate also on Plate XIX, Figs. 30 and 31, one of the continuous-current generators installed at the sub-stations. These are of 500-kw. rated capacity, generating current at 500 volts when making 145 r.p.m. We shall return to these in describing the sub-station at Tres Sargentos.

The switchboard supplied by Messrs. Brown, Boveri and Co., is arranged at one end of the turbine room. An elevation and a plan of it are represented in Figs. 32 and 33, annexed, and in Figs. 34 and 35 we show portions of board to a larger scale, whilst Figs. 36 and 37, Plate XX, have been reproduced from photographs taken at the back of the board. It is of the cellular type, with electric remote control, and is arranged for 20 outlet cables and with provision for coupling-up the two new large generators now being installed. A battery of accumulators having a rated capacity of 600 ampere-hours supplies current for operating the electric controls, and also as reserve for the excitation of the generators.

The general layout of the switchboard connections as arranged for the three generators originally installed is indicated in Fig. 40, page 221. The

Fig. 35.



bus-bars are in duplicate, so that any group of feeders can be operated from any machine, or any particular section of the bus-bar system can be isolated for cleaning without interruption of the supply. The machine-oil switches are electrically operated by electrically-controlled relays, whilst each generator has also its own automatic-pressure regulator controlling the excitation current of the exciter. As already mentioned, a reserve source of excitation is provided by a number of accumulators, the arrangements for charging which are shown on the left-hand side of the diagram. Both in the main power station and in the sub-station, very complete arrangements are provided for safeguarding the plant against the effects of possible lightning discharges. The speed adjustment of the turbines can be effected from the switchboard by means of an electro-magnetic control device fitted to each turbine, the plan of which is also shown in Fig. 40.

The electrical relays installed here for operating the oil switches are illustrated in Figs. 38 and 39, Plate XX, and in Fig. 41, Plate XXI. The mechanism is operated by push-button controls from the bench boards, located on the operating platform, that is to say, to open or close the distant oil switches the attendant simply has to make or interrupt the low-pressure circuit of the operating mechanism coupled to the switches. As shown in the figure, the operating mechanism consists of an electro-magnet with movable plunger, which latter is suitably connected to the spindle of the switch through the coupling shown on the left-hand side of Fig. 41. Similar relays are fitted at the sub-stations, a no-pressure release being added in that case as indicated in Fig. 41, on Plate XXI.

Figs. 42 and 43 show the pattern of oil switch used. They are of the makers' standard type, with the oil tanks on the base. This type of switch has been used throughout the whole plant.

The time-limit relay provided is represented in Figs. 44 and 45. It is of the two-pole induction type and is adjustable in respect to both time lag and the value of current at which it operates. The time lag is altered by varying the length of the cord carrying the weight to be wound up, while the current at which the relay operates can be regulated by alteration of the shaded pole. The function of this relay is to open the oil switch in the main circuit at a definite overload which has been sustained for a definite time. It does this by completing the circuit of a trip coil on the oil switch when the conditions arrive for which the relay has been adjusted. The action of the relay is shown on Fig. 46. The curves are plotted with the time lag as a function of the current strength for different positions of the movable pole piece, the length of the suspending thread being its full length in all cases.

One of the three-pole oil switches fitted with overload relay and no pressure release gear is represented in Fig. 48, Plate XXI. The switch itself is of similar type and construction to that represented in Fig. 42. The overload relays fitted represent the latest practice of the firm for direct operation, whereas that shown in the induction type of relay shown in Fig. 41 opens the switch by completing the circuit of a trip coil mounted on the switch. With the direct-acting type on the other hand, the relays themselves are mounted on the switch, and

ELECTRIC POWER SUPPLY AT BUENOS AIRES; SWITCHBOARD AND FITTINGS.

CONSTRUCTED BY MESSRS. BROWN, BOVERI AND COMPANY, ENGINEERS, BADEN, SWITZERLAND.

(*For Description, see Page* 221.)

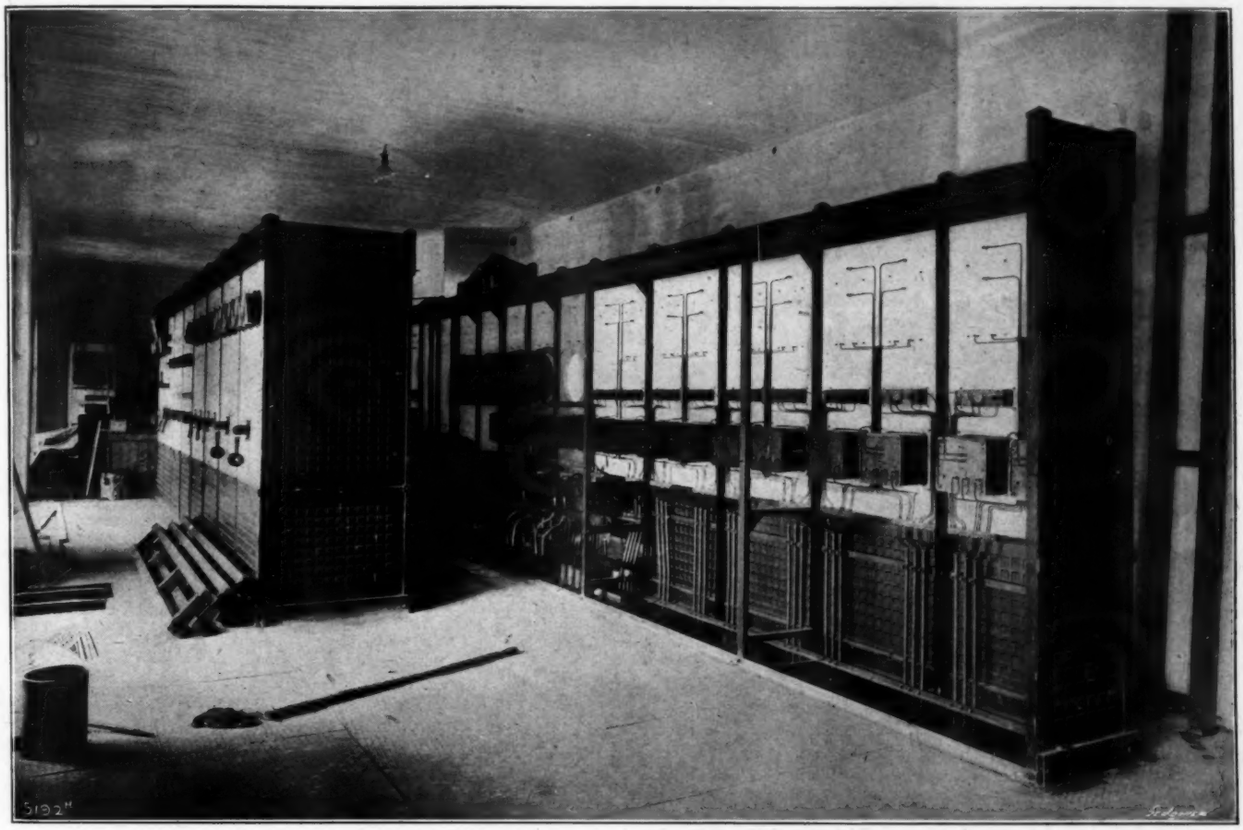


Fig. 36. Back of Switchboard at Pedro Mendoza Power Station.

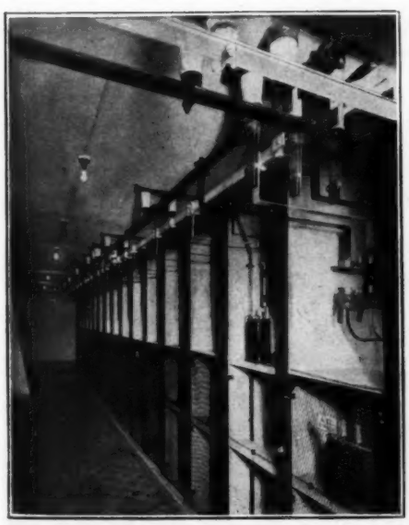
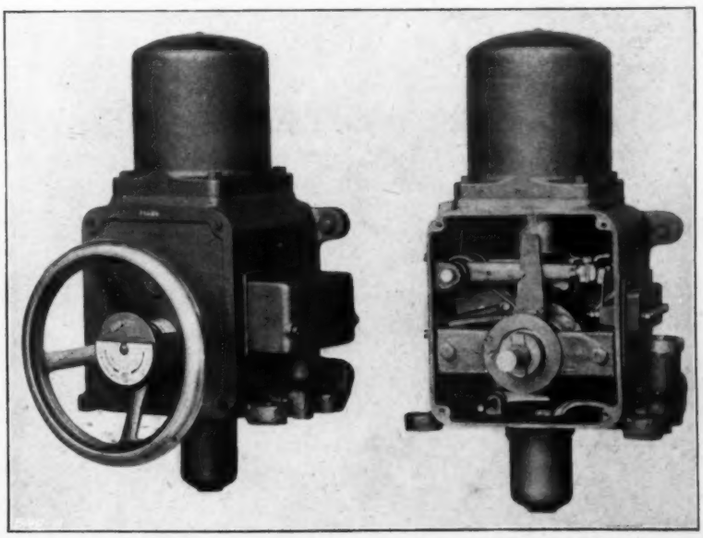


Fig. 37. Back of Switchboard.



Figs. 38 and 39. Electric Relay for Operating Oil Switch.

(*To face page* 222.)

ELECTRICAL POWER SUPPLY AT BUENOS AIRES; SWITCHBOARD FITTINGS.

CONSTRUCTED BY MESSRS. BROWN, BOVERI AND CO., ENGINEERS, BADEN, SWITZERLAND.

(*For Description, see Page* 221.)

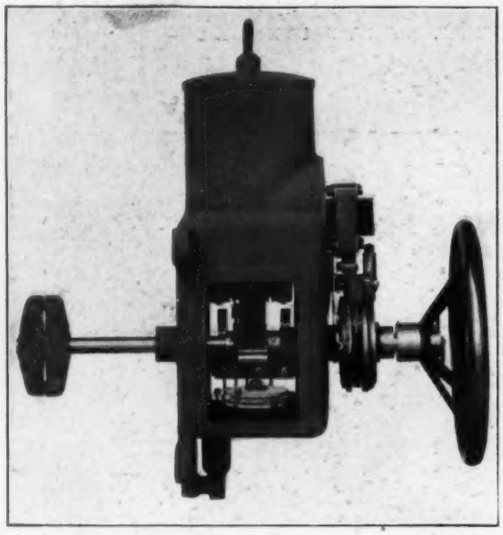
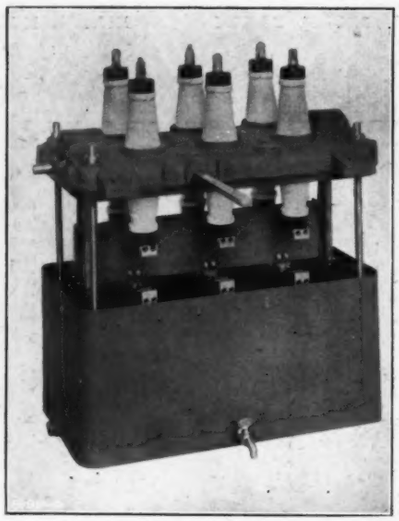
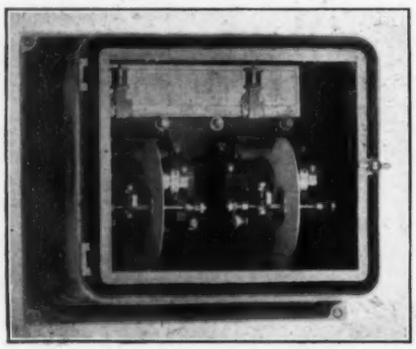
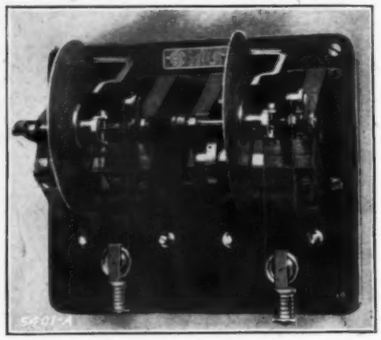


Fig. 41. Electrical Relay for Operating Oil Switch.



Figs. 42 and 43. Oil Switches with Oil Tanks in the Base.





Figs. 44 and 45. Two-Pole Time Limit Relay.

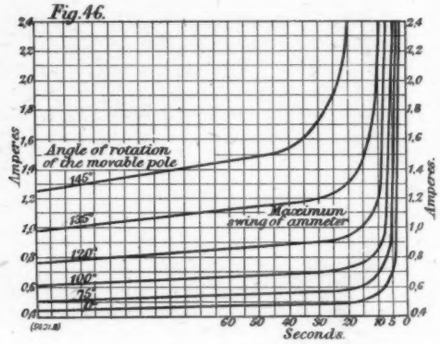


Fig. 46. Diagram showing Time Lag of Relay.

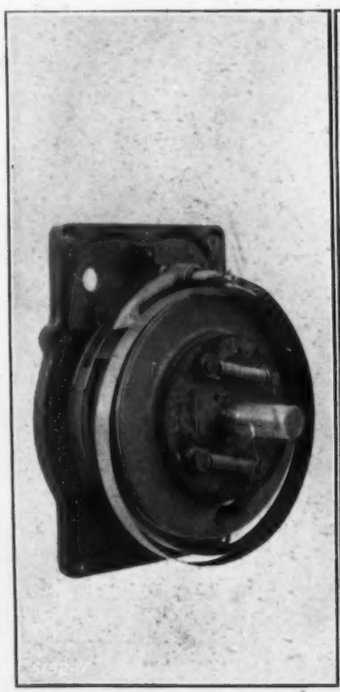


Fig. 47. Free-Wheel Couplings for Oil Switch.

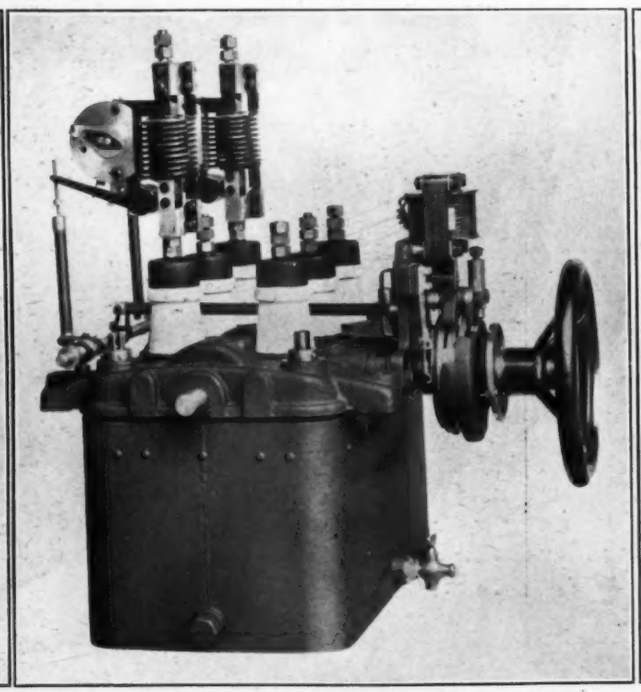


Fig. 48. Oil Switch with Overload Relay and No-Pressure Release Gear.

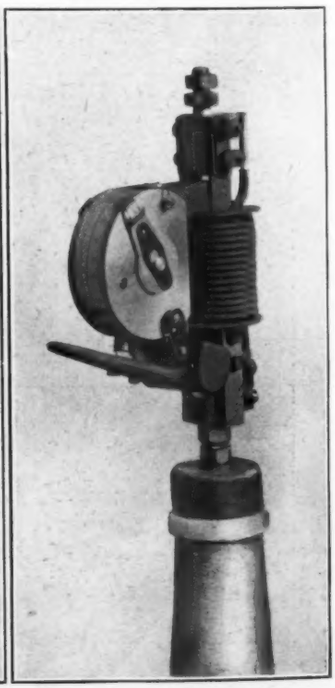


Fig. 49. Overload and Time Lag Relay.

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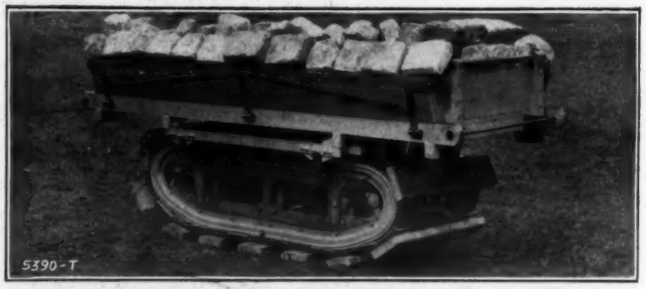
TRACTION ON BAD ROADS OR LAND.

(*For Description, see Page* 239.)



FIGS. 150 AND 151. PEDRAIE CHAIN APPLIED TO HAULAGE WAGON FOR STONE.

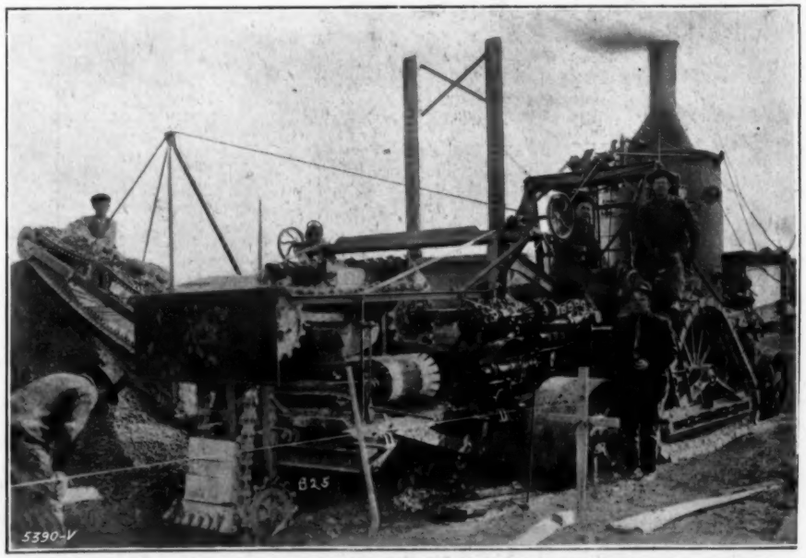


FIG. 152. PARSONS' MODEL 60 TRENCH EXCAVATOR.

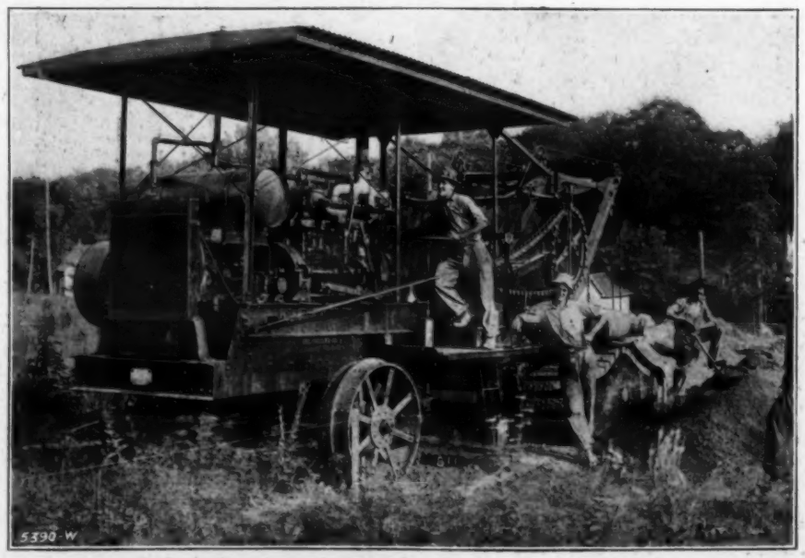


FIG. 153. PARSONS' MODEL 48 TRENCH EXCAVATOR.

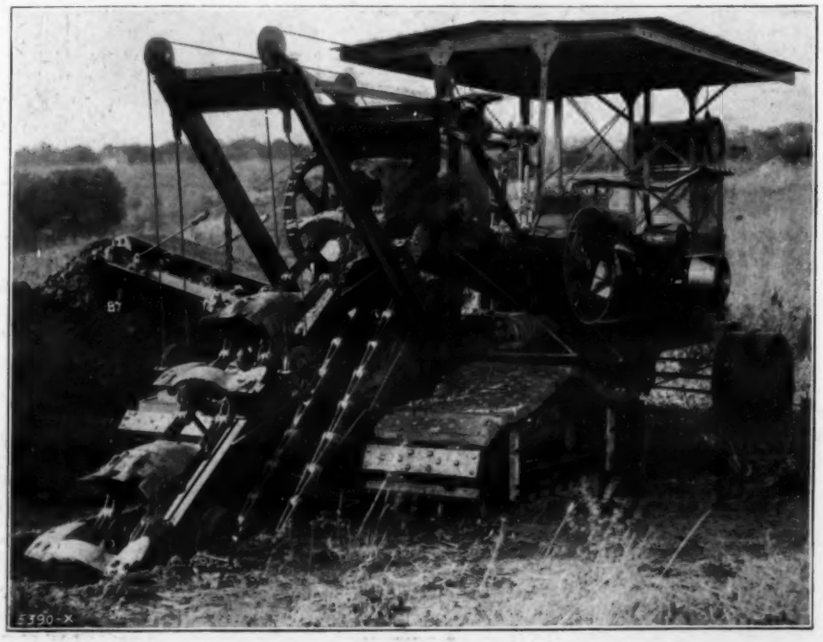
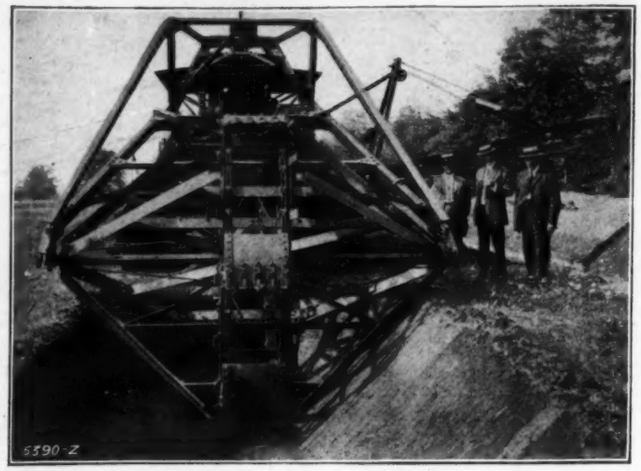


FIG. 154. PARSONS' MODEL 24 TRENCH EXCAVATOR.

(*To face page* 240.)

TRACTORS ON BAD ROADS OR LAND.

(*For Description, see Page 239.*)



FIGS. 155 AND 156. THE AUSTIN DRAINAGE EXCAVATOR.

FIG. 158. A RENARD ROAD TRAIN.

FIG. 157. A BACKFILLER.

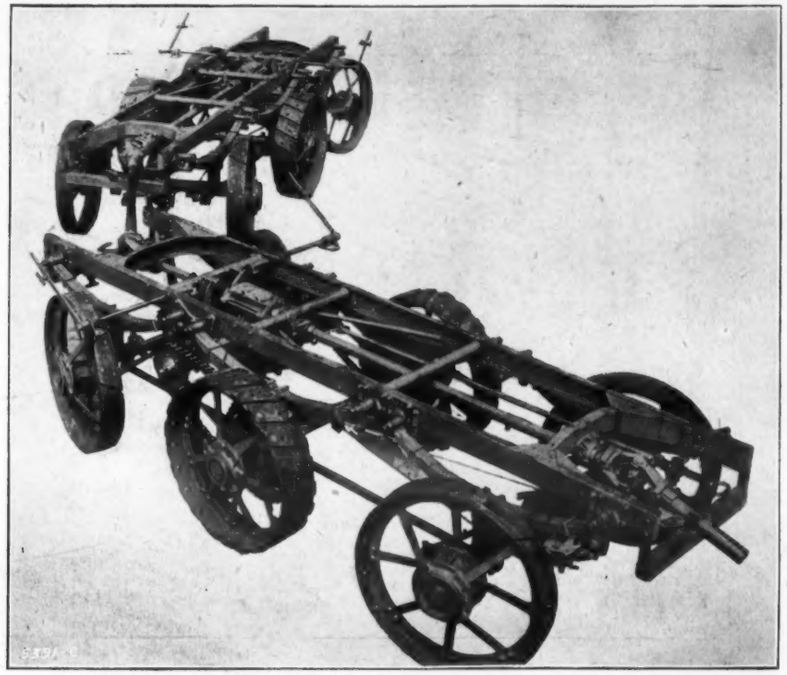
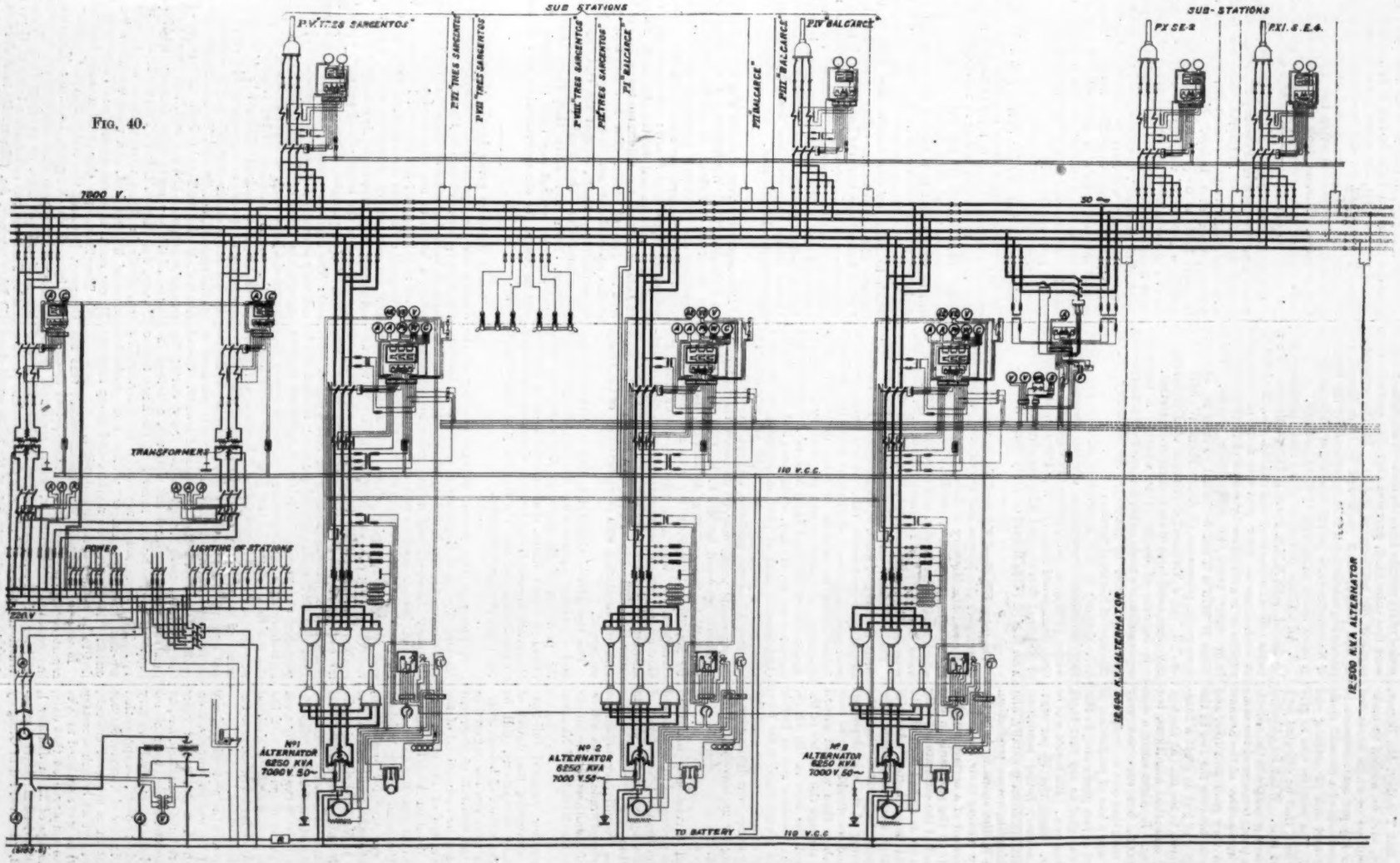


FIG. 159. CHASSIS OF RENARD ROAD TRAIN VEHICLES.

(*To face page 241.*)

ELECTRIC POWER SUPPLY AT BUENOS AIRES; SWITCHBOARD CONNECTIONS FOR THREE GENERATORS.

Fig. 40.



open the latter by tripping it at a definite overload which has been sustained for a predetermined time. The no-pressure release can also be seen from this illustration—it opens the switch in the event of failure of the supply.

This switch is arranged for hand operation, the operation taking place through a free-wheel type of coupling, as shown in the illustration, Fig. 47, Plate XXI. This coupling enables the switch to be put on, but thereafter it can only be opened by operation of the trip gear, so that, for instance, it cannot be held closed on a short circuit.

Fig. 49 shows a relay of the direct-acting type above referred to. Such relays are mounted on the switch insulators and constitute terminals, the current passing through the series coils of the relay to the switch, so that no current transformers are required as is the case with the induction type of relay. This new class of relay can be readily adjusted to meet different conditions of overload and time lag by means of the lever at the side of the casing which, as will be seen, terminates in an index moving over two scales, one showing time in seconds and the other current strength.

(To be continued.)

JAPANESE RAILWAY ENTERPRISE.—According to *The London and China Telegraph*, Japan will be one of the many countries eager to import railway material of all descriptions after the war, since it is extremely unlikely that the different railway developments contemplated in that country can be carried out with locally manufactured supplies. The proposal for the construction of a light underground electric railway in Tokyo has been discussed again, the overcrowding on the Tokyo tramways having called attention to its desirability. The scheme is preferred to the establishment of an omnibus service, by reason of the narrow streets. A line 9 miles in length is proposed, but it is recognised that it will take five years before such a system could be completed. There has also been a revival of the scheme for increasing the gauge of the Japanese Government railways.

INDUSTRIAL NOTES.

SPEAKING in Parliament last Tuesday, Mr. Barnes, Member of the War Cabinet, said he wished to make it clear that the Labour Commissions which he started had nothing to do with the 12½ per cent. increase in wages. The 12½ per cent. arose out of a promise made on the floor of the House and out of nothing else so far as he was concerned. The promise was to give a rise in wages, and it was said that he objected to a rise in wages; this was not true. What he objected to was the introduction of a new principle in the adjustment of wages. Up to that time, bonuses of the same amount were given to men irrespective of the amount of their wages. That was a very good principle, and he had wanted to maintain it, because the rise in the cost of food and other things was just as great a hardship to the man at the bottom as to the man at the top. The 12½ per cent. not only concerned munitions, but any workshop in the country. It might mean a cost of 14,000,000*l.* or 40,000,000*l.*, but that was only a fraction of the cost if they took that cost as compared with loss of output. There was a loss of production to the country in the latter part of last year owing to this industrial ferment, but he was glad to say that there was a very great improvement now. His desire was to encourage the piece worker. Since the 7½ per cent. was given to the piece worker, better conditions prevailed, the shops were settling down generally, and he believed there was something like normal production.

He appealed to the men in the shops to help the country through the war by putting their backs into their work. Last month, instead of a certain number of ships being turned out from the shipyards in this country, we had less than half of the estimate actually turned out. This month, so far as he had been able to ascertain, the position would be no better. America was failing us so far as ships were concerned. The shipyards were even of more importance than the munitions shops. The winning of the war depended upon the output of ships, and we should have to turn out ships in far larger numbers than we had turned out so far if we were to get through the trouble of the next few months. He urged the men in the shops, in justice to the men in the trenches and in justice to the old country which had always stood in the forefront of freedom, to turn out ships in greater quantity, so that we could do our duty to the men fighting for us on all the fronts, and fighting for us bravely, and not getting 6*l.*, 8*l.* or 10*l.* a week.

The Minister of National Service has issued an instruction laying down the procedure to be followed with regard to the protection from military service of officials of recognised trades unions which were in existence on February 1, 1918:—

1. The names of full-time executive or organising officials and district secretaries of trade unions will be forwarded to the Ministry of Munitions by the unions concerned, for submission to the Ministry of National Service on Form M.M. 81.

2. Branch secretaries, whether engaged full-time in trade union duties or combining the duties of secretary with their ordinary occupations, will be dealt with as follows: (*a*) The names of branch secretaries of trade unions whose members are engaged in industries dealt with under the Schedule of Protected Occupations will be forwarded by such official of the union as the executive committee of the union may appoint to the appropriate Munition Area Recruiting Officer, who, after reference to the Munitions Area Dilution Officer, will pass the same to the Assistant Director of Recruiting of the Area for verification. The Assistant Director of Recruiting will forward the applications to the Director of National Service of the Region for his sanction to the protection of the official recommended. (*b*) The names of branch secretaries of trade unions which do not come within the Schedule of Protected Occupations will be forwarded by such official of the union as the executive committee of the union may appoint direct to the Director of National Service of the Region in question for his sanction to the protection of the official recommended.

3. Sanction will not be given to the protection of any branch secretary unless (*a*) he was so employed on February 1, 1918, and (*b*) he had attained 32 years of age on January 1, 1917, or, if under that age, has, on his last authorised medical examination been placed in Grade 2 or 3, or classified in a medical category lower than "A." By way of exception, an application may be entertained, if the Director of National Service of the Region considers that there are good grounds, on the part of a man appointed as branch secretary after February 1, 1918, if (*a*) he was appointed to take the place of another man so employed at that date, and (*b*) he had attained the age of 32 on January 1, 1917, and has, on his last authorised medical examination been placed in Grade 3, or classified in Category B 2, C 2, B 3 or C 3.

4. The names of all officials whose protection is sanctioned under paragraphs 1 and 2 above will be entered in the register as not to be called up for a period of six months from the date on which their names were first submitted, provided that they continue to be engaged on trade-union duties. At the expiration of this period, their cases will be reconsidered, and protection continued if still considered by the Director of National Service (or the Minister of National Service in cases under paragraph 1) to be justified.

5. All officials protected under this Instruction will be issued with M.N.S. Form R 3476, endorsed "Trade union official protection under N.S.I. No. 22 of 1918," at such time as their previous form of exemption expires or is withdrawn by reason of their transference from their trade to trade-union duties. M.N.S. Form R 3476 will not be issued so long as any man remains in possession of Army Form W 3476 "A" or "B," or a Tribunal Certificate of Exemption, or any other valid form of exemption or protection.

6. In case of doubt as to whether a particular organisation is a trade union covered by this Instruction, reference should be made to the Secretary (R. 3), Ministry of National Service.

7. Nothing in this Instruction in any way affects any individual trade-union official, instructions for whose protection have, before the date of this Instruction, been issued from the War Office or the Ministry of National Service, and who has already been issued with M.N.S. Form R 3476 or Army Form W 3476.

The Iron and Steel Kindred Trade Central Advisory Committees (Employers and Operatives), which advise and assist the Ministry of Labour on questions arising in the administration of the Employment Exchanges, which affect these trades, met together at the Employment Department on February 21, Mr. J. S. Nicholson, representing the department, being in the chair.

The meeting considered the proposal that Employment Exchanges, when submitting men for vacancies, should give preference, other things being equal, to men who have been discharged from His Majesty's forces owing to wounds or other disability. After discussion, a resolution was proposed by Mr. George Ainsworth, of the Steel Ingot Makers' Association, and seconded by Mr. Walker, of the Iron and Steel Trades Confederation, and adopted unanimously, to the effect that such a preference should be given during the continuance of the war, and without prejudice to the arrangements which may be necessary thereafter. A resolution proposed by Mr. F. W. Gilbertson, of the South Wales Siemens' Steel Association, and seconded by Mr. Tom Griffiths, of the Iron and Steel Trades Confederation, was also passed, stating that the Government should be urged to lose no time in submitting proposals for dealing with demobilisation, in order that difficulties which may arise may be dealt with in consultation with representatives of the trades concerned.

The Operatives' Committee held a further meeting and considered, among other matters, the question of the provision of Employment Exchanges and local offices in South Wales, the representation of Distress Committees on the Local Advisory Committees attached to the exchanges, and the frequency of signature of the Unemployment Register.

Speaking at the annual general meeting of the Machine Tool and Engineering Association, Limited, on February 21, Mr. J. Judson, of the Judson-Jackson Company, Limited, said it was going to be difficult for the British machine-tool makers to compete in the world's markets, owing to the fact that our friendly and respected American rivals had amassed huge reserves during the war period, which reserves will enable them successfully to travel and advertise, and do everything possible to secure the trade. The production of machine tools in the States during 1915, 1916 and 1917 was equal, in quantity, to that of the preceding ten years. The prices of American machine tools have gone up tremendously, which means that the individual firms in the States are exceptionally well placed for after-war trading. In this country, the prices of British tools have not advanced abnormally, and even if they had, the surplus would be swallowed up in excess profits, &c., as the pre-war standard of profits in any firm is the only basis of reward. One of the most deplorable things he had found during the past two years was that the workmen measured the supposed profits by the number of machines turned out. They were not educated up to understanding pre-war standards, excess profits and controlled prices. He believed the machine-tool group were the first to be put under controlled prices.

It was to be hoped, Mr. Judson added, that the report on the position of the machine-tool trade on the cessation of hostilities, when presented to the Minister of Munitions and the Minister of Reconstruction, would deal fully with the precarious position in which the general members of the trade would stand as compared with competitors overseas, and they were the people from whom we had to take our standards of dealings; if they travelled, we had to travel; if they advertised largely, so had we to do the same; if they planed a given size lathe-bed in 10 hours, so must we. At the present time, the country was spending something like 7,000,000*l.* per day for destructive purposes; he suggested that an equivalent amount should be spent for a short period after the war on constructive purposes. Machine tools were the basis of everything.

When the war is over, said Mr. Ch. W. Hunt, in a paper which he read on February 23, before the Manchester Association of Engineers, there will be a very wide field for the engineer salesman, larger and wider, perhaps, than ever before. Not only will manufacturers have to be prepared quickly to switch off making munitions of war, and promptly go on with regular productions of the requirements of peace, and those things which belong to the vocations of peace—much of it, naturally, of an electrical or a mechanical nature—but they will have to cater for it differently from what they have ever done before. Their commercial side will require a great deal of overhauling and reconstruction if they are to take advantage of the sacrifices of the war and of the lessons which other nations have taught us.

We read in *The Marine Journal*, New York, that the American Shipping Board is planning the establishment of a volunteer reserve army of 250,000 mechanics from which to provide labour as needed for the shipyards. Men of draft age who enlist in this reserve will doubtless be freed from military service. Housing will be worked out as a part of the plan, and transportation will be provided for. It is proposed to make the State Councils of Defence the agencies through which to build up this reserve and have them cooperate with employment offices established by the United States Department of Labour. It is anticipated that there will be a very satisfactory response, as many patriotic, skilled American workers are waiting anxiously to be told what service they can best render. In the last six months, the number of workers in the United States shipyards has been trebled, and now approximates 150,000 men.

Five representatives of capital and five of labour met on February 26, at Washington, at the suggestion of the Secretary of Labour, to consider the relation of employers and employees during the war. The representatives of the employers were chosen by the National Industrial Conference Board; the spokesmen of the employees were named by the American Federation of Labour. These ten will name two others to represent the general public. The first aim is to prevent strikes and lock-outs and to assure continuous work on Government contracts, so that the Government need not commandeer either plants or labour for war production. Both sides agree that there shall be no discrimination against any class of labour. A basis will be sought for the determination of a permanent wage.

Recent decisions given by the Committee on Production and the Special Arbitration Tribunal on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given, cover:—(1) Riggers, &c. (Messrs. Harland and Wolff, Liverpool): The men concerned are plain time workers and are engaged on munitions work, viz., work in connection with repairs to Admiralty vessels. They are entitled to the bonus of 12½ per cent. under Order 1308. (2) Shipwrights (Ship-repairing Trade, Swansea): The men concerned are not plain time workers, and they are not entitled to the bonus of 12½ per cent. on earnings under Order 1301. They will receive the bonus of 7½ per cent. on earnings under the Government's recent decision from January 1, 1918. (3) Packing-case makers (Glasgow): The men concerned are to receive an advance of 1½*d.* an hour from the beginning of the first full pay in January, 1918. (4) Galvanisers, &c. (Messrs. Thomas Harbutt and Co., Limited, Walker-on-Tyne): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. from January 1, 1918. (5) Testers, &c. (Messrs. Lloyd's Proving Houses, Netherton, Dudley): Plain time workers are to receive a bonus of 12½ per cent. and piece workers a bonus of 7½ per cent. on earnings as from January 1, 1918. (6) The Telegraph Construction and Maintenance Company, Limited, the Gutta Percha Company, and the Union Cable Company, Limited: The men concerned who are plain time workers are to receive a bonus of 12½ per cent. on earnings from January 1, 1918. Piece workers to receive a bonus of 7½ per cent. (7) Wire workers, &c. (Messrs. Richard Johnson and Nephew, Limited, Manchester): Plain time workers

are to receive a bonus of 12½ per cent. on earnings, and piece workers 7½ per cent., from January 1, 1918.

The Bureau of Labour Statistics of the United States Department of Labour, says *The Iron Age*, has just published Bulletin 218. The record ends with May, 1915, a time when the late general depression in the iron and steel industry was lessening, but when hourly earnings were still at a low level. The depression, while not affecting the rates of pay which had been materially increased in the spring of 1913, did, by affecting the tonnage output and the incentive for rapid work, so decrease the earnings per hour of tonnage workers, that the combined full-time weekly earnings of time and tonnage workers in May, 1915, as compared with May, 1913, were decreased 4 per cent. in blast-furnaces, 10 per cent. in Bessemer plants, 1 per cent. in open-hearth plants, 5 per cent. in blooming mills, 3 per cent. in standard rail mills, 4 per cent. in bar mills, and 5 per cent. in sheet mills. The weekly earnings in plate mills were unchanged, and tin-plate mills showed an increase of 3 per cent.

In the period between January, 1915, and January, 1917, approximately 100 per cent. of the principal iron and steel plants of the United States reported an increase in employees of over 50 per cent. and in total pay rolls of over 125 per cent.

The reduction in seven-day work through the introduction of relief gangs which began in 1910, increased to such an extent that in blast-furnace plants, in which operations are continuous, only 59 per cent. of the employees worked seven days per week in 1915, as compared with 80 per cent. in 1913, 95 per cent. in 1910 and 97 per cent. in 1907.

Average full-time weekly earnings in iron and steel industry for 1915 are shown in the following list :—

	Dols.
Blast Furnaces—	
Labourers	12·20
Keepers	18·33
Blowers	26·93
Bessemer Converters—	
Mould cappers	17·53
Steel pourers	27·96
Vesselmen	30·87
Sheet Mills—	
Openers	11·93
Doublers	19·42
Sheet heaters	37·19
Open-hearth Furnaces—	
Stockers	15·41
Stopper setters	21·96
First melter's helpers	32·80
Blooming Mills—	
Bottom-makers' helpers	12·46
Manipulators	25·81
Heaters	40·06
Plate Mills—	
Shearmen's helpers	17·89
Table operators, sheared	22·63
Screwmen, sheared	32·61
Bar Mills—	
Bundlers	13·38
Roughers	25·76
Rollers	56·75
Standard Rail Mills—	
Hotbed men	12·54
Table lever men	22·92
Rollers	43·09
Puddling Mills—	
Bloom boys	10·62
Puddlers	20·45
Heaters	36·37
Tin-plate Mills—	
Screw boys	16·59
Catchers	20·87
Shearmen	29·55

A similarity in earnings does not indicate a similarity in full-time weekly hours. For example, the full-time weekly earnings of blast-furnace keepers were only 1.09 dols. less than those for sheet-mill doublers, but the average full-time hours per week of keepers was 79.4, while that of doublers was only 42.8. The rate of wages paid common labourers is to a large extent a basic rate, from which are determined the rates for other occupations requiring little skill, hence the rate for common labour is of importance beyond the limits of the occupation proper. The average rate per hour of labourers in 1915 in the ten departments covered was 18 cents, while the average full-time hours per week ranged from 57.5 to 74.3 and the average full-time weekly earnings from 9.66 dols. to 14.31 dols.

PERSONAL.—Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, have appointed Mr. Ernest T. Wilson to represent their interests at 8, Great George-street, Westminster, so far as regards the following: High-speed and carbon steels, small tools of all descriptions, hand-screwing apparatus, and, in addition, machine tools.

SIGNALLING AND INTERLOCKING OF KEADBY RAILWAY AND BRIDGE.*

By JAMES BENJAMIN BALL, M.Inst.C.E.

(*Concluded from page* 174.)

Interlocking Frame.—For the operation of the signals, points and special apparatus peculiar to the bridge protection, an interlocking frame of 28 levers is provided in the cabin. Of these, six levers are used for the up and down line signals, two for the sand-drag points, two for bolt-locks to cross-over and siding connections, one for each of the rail-detectors, east and west, one each for the bridge-bolt, king lever, road warnings, gate stops and river signals, whilst the remainder are spare spaces. The interlocking frame is designed with a view to the easy accessibility of all parts from the point of view of maintenance.

A side elevation is shown of the signal and switch levers in Figs. 11 and 12, and a front and end view of the locking frame in Fig. 13, page 226 (with the casing removed) show the relative positions of the operating lever and contacts, indicating contacts, solenoid indication magnets, relays and terminal board. The framing consists of cast-iron standards, front and back tie-pieces, and, together with the locking-boxes, is built in sections of four or eight levers. The terminal and bus-bar board is placed at the lower back part of the frame, and all fuses and terminal posts are directly under their respective levers, and lettered for identification in accordance with the circuit plan. The lever castings are screwed to the tie-pieces or bridges at 3 in. pitch. Electric locks on certain levers are provided, these being fitted upon the lever cover, the lock engaging in a notch or notches cut in the upper edge of the lever slide. The polarised relays, one for each lever circuit, are mounted in line upon a shelf at the back of the frame. These relays are provided with a soft iron magnet placed lengthwise between the poles of a permanent magnet, and are used for detecting the presence of foreign or stray currents in the circuits, and will be referred to later under "Cross Protection." The indication-selector, one for each switch-lever circuit, also mounted at the back of the frame, consists of a simple design of two electromagnets and an armature fitted with contacts, these contacts being closed in one direction when the lever is reversed and in the opposite direction when the lever is normal.

Above the interlocking frame is a diagram of the track and signals, showing the tracks divided into sections which correspond with the track-circuit sections controlling the various signals. Each section is clearly distinguished by different colours from the adjoining sections. In the centre of each section an indicator with one red and one white disc is fixed. These discs are eyeball shape, and are operated by an electromagnet. The normal (energised) position of these indicators would show "white" with the track unoccupied, and "red" (de-energised position) when the track is occupied by a train or vehicle or failure of current. With the aid of this diagram the signalman can follow the position of trains through the area within his control under all weather conditions.

The design of the interlocking frame and the controlling circuits presents several features essential to safety and facility of operation :—

1. Means are provided for checking the correspondence of movement between the lever and points, signal or other apparatus to be controlled. This is obtained by means of dynamic indication, the energy being furnished by a momentary dynamic current generated by the motor only when such points or other apparatus have been fully worked to their correct position and locked. The use of dynamic current prevents the chances of a false indication due to a cross between the wires of the circuit.

2. Means are provided for preventing unauthorised movement of points, signals or other functions through foreign or stray currents.

3. Means are provided for giving an automatic movement to the lever bar, thereby completing its full stroke,

Fig. 11.

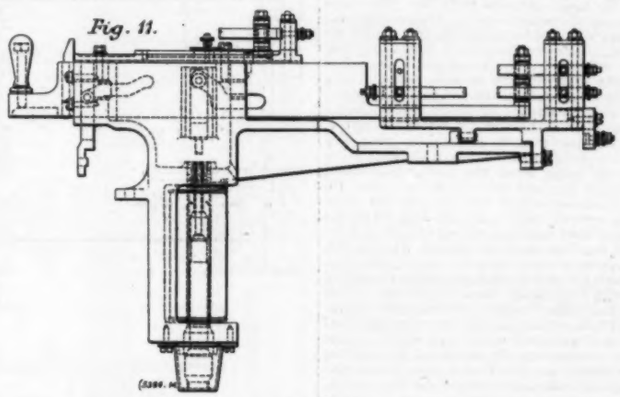
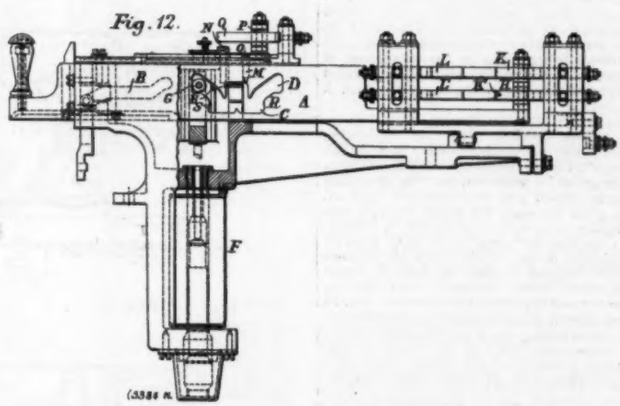


Fig. 12.



and indicating the correctness of the movement freeing the locking for operation of dependent levers.

Taking the operation of switch lever No. 11 (Fig. 12) as an example, it will be seen that the lever bar A is provided with a cam-slot B, which transmits motion to a tappet for effecting the ordinary mechanical locking. By means of a slot C with right and left-hand cam faces D and E, an automatic indication stroke is given to the lever by means of a solenoid magnet F, the connecting rod roller G of which acts on the inclined cam faces D and E for reverse or normal indication respectively. An extension of the lever bar carries an insulated circuit-maker H, which makes and breaks contact with two pairs of normal and two pairs of reverse operating spring contacts K and K1 and L and L1 respectively. A pin M screwed to the top end of the lever bar operates in a slot N of a movable plate O; to this plate an insulated circuit-maker P is attached, so arranged that when the lever bar is pulled the plate O is moved at the end portion of the stroke by means of the pin M and the attached circuit-maker P makes contact with the fixed indicator spring contact Q. The breaking of these contacts takes place upon the last portion of the automatic movement of the lever when going to reverse or normal. The points are unlocked, worked and locked by the switch and lock movement shown in Fig. 14, which is driven by a series-wound 110-volt direct-current motor. One normal and one reverse wire is used for the control; the normal control wire is also used for the reverse indication and the reverse control wire for the normal indication. A main common wire is connected at each switch location.

The point-operating mechanism is contained in a weather-proof casing, and consists of the motor A, spur gears B, friction clutch C, main or cam-gear D, pole-changer E, switch drive rod F, locking bar G, and detector H.

* Paper read before the Institution of Civil Engineers and reproduced by permission from the Minutes of Proceedings.

Operation.—To reverse the points the lever bar A (Fig. 12) is pulled the first portion of its stroke about 2 in.; this stroke is limited by the roller G of the solenoid connecting rod butting against the vertical shoulder R of the horizontal slot C. It effects:—

1. The preliminary actuation of the mechanical locking by means of the camslot B.
2. The making of the reverse operating springs L, L^1, by the circuit-maker H.
3. The making of the indication springs Q by the circuit-maker P.

Referring to the wiring diagram (Fig. 15), the operating circuit is completed through the coil of the safety relay 1 (ensuring the breaking of the local indication circuit through contact springs 21 and 22), coil 3 of the selector relay (making contact with the springs 4 and 5), reverse contact spring 6, wire 7, coil 8 of pole-changer, contact 9 and back to battery by main common wire 10, thus completing one path of a circuit for holding the pole-changer contacts 11 in the position shown. The second path of a circuit from wire 7 passes through the contact 12, motor armature 13, contact 14, field-coil 15 and back to battery by main common wire 10. The completion of this circuit starts the motor. The facing point lock bar is raised, the points unlocked, the points reversed and locked, the facing-point lock bar is lowered. The points are unlocked, the facing-point lock bar thrown, the points reversed and locked. At the end of the stroke the pole-changer is tripped to the opposite position; this action breaks the motor-operating circuit and current ceases to flow through the safety magnet 1. The overrun of the motor now comes into play and develops a momentary dynamic current in the indication circuit, the circuit being from the motor armature, pole-changer contact 16, field-coil 15, return wire 10, polarised relay 17, safety relay coil 18, selector relay contacts 4 and 5, reverse contact 19 and wire 20 to the motor armature. This completes the circuit to attract the armature 23 to close contact springs 21 and 22, thus setting up a local circuit from the battery through safety-relay contact springs 21 and 22, indicator-spring contact N, solenoid magnet 24, back to battery. This circuit energises the solenoid magnet, and the connecting-rod roller G (Fig. 12), acting on the cam portion D of the indication slot C gives an automatic stroke to the lever bar, thereby completing the stroke of the locking tappet by means of the cam-slot B, and also breaks the local indication-circuit at the indication contact springs N. To place the points normal, a similar sequence of movements takes place. Wire 20 becomes the normal operating wire, and reverse operating wire 7 becomes the return indication wire; the eventual automatic normal movement of the lever being given by the energising of the solenoid magnet 24 bringing into play the operation of its connecting rod and roller G, acting on the cam E of the indication slot C.

Cross Protection.—For cross protection, a no-voltage release reverse current-breaker with its indicating red lamp and a polarised low-resistance relay of a similar type to that inserted in each circuit governing a switch, signal or other function is provided on the operating switchboard. These relays are so connected that all working currents pass through the relay coils in one direction to maintain a closed contact, whilst foreign or stray currents on the operating wires pass through the relay in an opposite direction and cause the contact to open. This open contact breaks the control circuit of the cross-protection circuit breakers, and thereby opens and cuts the current supply to the system. Fig. 16 shows a simplified circuit illustrating the principles of the cross-protection system. In a signal operation, a dynamic return indication stroke of the lever is only given for the normal position of the signal, whereas a switch lever is provided with dynamic indication for positions.

A switch lever with its solenoid indicating magnet, selector safety relay and switch and lock movement is utilised for the operation of the rail plungers, detector apparatus and bridge circuit-closers; the operating and dynamic indication circuits are the same as described in connection with No. 11 point lever. Fig. 17 shows the general arrangement of the apparatus at the nose of the lifting span. The first operation of the movement is to withdraw the detector bolt A and break the circuit connections by means of the bridge circuit-closers B, operated by rocking-shaft connection C.

The rail plungers D, E, F and G are then withdrawn by rocking-shaft connections H, and a final movement of the detector bolt A detects the proper reversal of the rail plunger, and dynamic current is generated by the motor to give the necessary automatic indication stroke to the operating lever No. 16. An identical arrangement of apparatus is provided for lever No. 17 at the heel end of the lifting span.

Fig. 18 shows a view of the bridge circuit-closer; three six-way and one ten-way types are used. The device consists of box A, with substantial contact jaws B, so adapted on a baseplate C as to allow for a lateral movement not exceeding 1½ in. On the operating side a cast-iron box D is provided with contact-making blades E, and a centering device F. When the lifting span is fully lowered, the centering device F is moved forward until the horns G and H ensure alignment of the laterally-movable box A, further movement of the connection F by means of slot J of the contact-maker driving rod K, butting against the shoulder of the centering device, forces the contact-making blade E to enter the contact jaws B. The full stroke of the driving member is 13 in.

River Signals.—To control these, a signal lever (No. 5 in the frame) is used, having a battery indication which is given on the normal position only. The lights (north and south) are shown in Fig. 3, page 173 *ante*. On the west pier a fixed red light is provided. On the second pier from the westward, a 2-ft. beacon ball being raised to the top of a 25-ft. mast, indicates by day when the span is about to be lifted. A red light is shown on the centre-line of the pier at a height of 6 ft. above the light on the nose end of the span, which changes to green when the lever is first pulled, and eventually to white through a contact on the limit switch when the span has attained the 45-deg. position. The light on the lifting span is a white light, but being shaded in the normal (down) position of the span by a red glass screen, it shows white only when the bridge is lifting or at rest in the lifted position. Two fixed red lights are provided on the pier at the heel end of the lifting span. The lamps used are fitted with Fresnel lenses in all cases, and illuminated through an arc of 180 deg.

The lighting circuit passes normally through the back contacts of two de-energised relays, A and B. When the lever is pulled, the reverse circuit energises relay A, and at the same time displays a sign "LIFT" to the ball-signal operator. The lighting circuit is now changed through the relay front contacts to light the "green" lamps. A tap off the reverse circuit passes to a contact on the limit switch of the lifting span, and as soon as the contact is made at the 45-deg. position of the leaf, the relay B is energised, and the lighting circuit is again changed to show white. The display of the white light on the pier by night with the white light on the lifted span, and the two fixed red lights on the pier at the heel end of the opening span, indicates to river traffic "channel clear."

Placing the lever to normal, the red light is immediately displayed on the pier, and the sign changed for the ball-signal operator from "LIFT" to "LOWER." The span being fully lowered, the white light on the nose end is screened to show "red." A battery indication is established, passing through the indicator magnet, indication contact, and normal operating-lever contacts, back contacts B and A and ball-signal normal contact to complete the automatic stroke of the lever.

Current Supply.—The 110-volt current supply for the signalling is obtained from one-half of the main battery (220 volts), which is used for supplying power to the bridge motors. Counter E.M.F. cells are installed to regulate the voltage on the signalling and lighting mains. The current supply for the track circuits, indicators, &c., is obtained from a set of 14 accumulators installed in the main battery house. This supply serves all the low-voltage circuits on the eastern side of the bridge. Two batteries of Tudor accumulators housed on the western side of the bridge are arranged to supply current at 110 volts and 25 volts. The 110-volt supply is for the roadway lighting, whilst the 25-volt supply feeds the track and low-voltage circuits on the western side between the bridge and the canal. A 25-h.p. petrol engine, driving generators of 37 volts, 175 volts and 110 volts on a single shaft, is used to charge the accumulators.

The engine is fitted with dual ignition, and is water-cooled. The 110-volt battery has a capacity of 460 ampere-hours, the capacity of the 25-volt battery being 280 ampere-hours. The 110-volt and 25-volt supply,

SIGNALLING AND INTERLOCKING AT KEADBY BRIDGE.

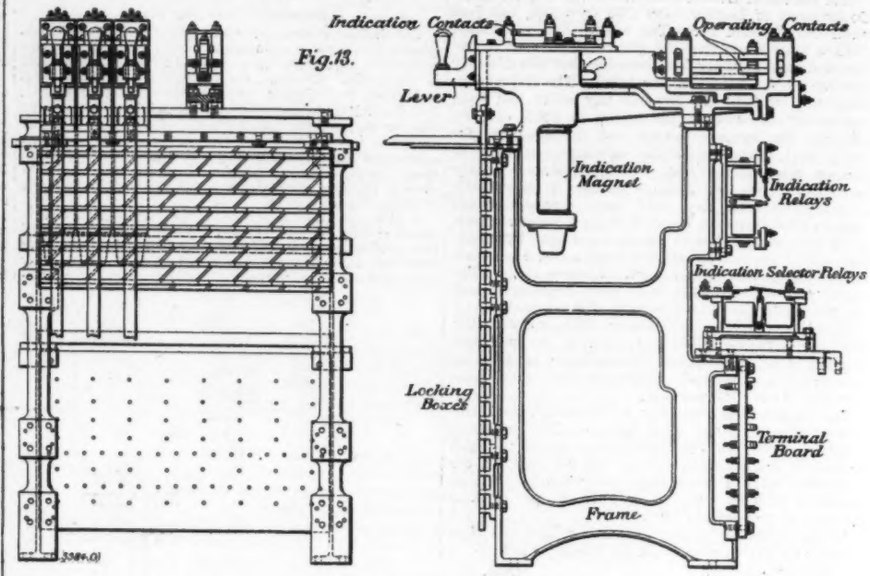


Fig. 13.

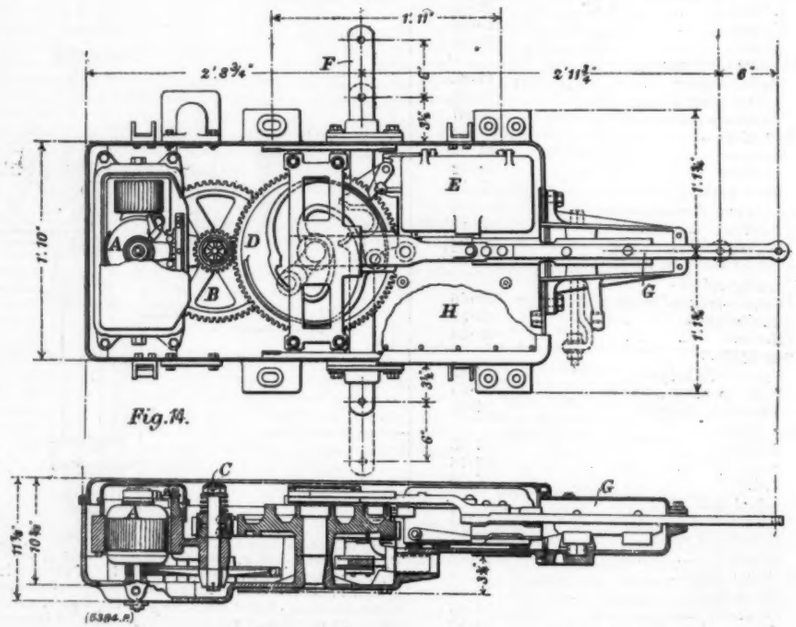


Fig. 14.

SIGNALLING AND INTERLOCKING AT KEADBY BRIDGE.

Fig. 15. G.C.R. KEADBY BRIDGE CABIN

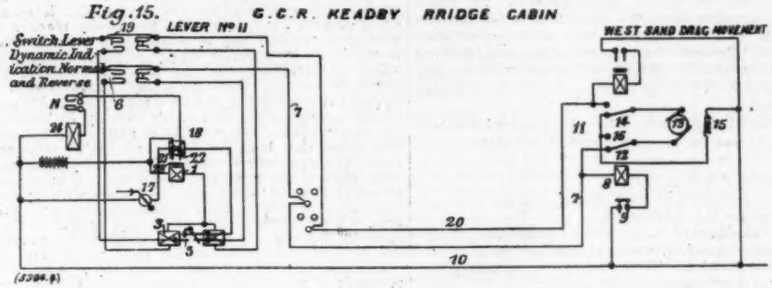
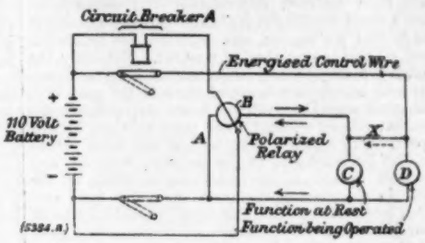


Fig. 16. SIMPLIFIED CIRCUIT SHOWING THE PRINCIPLES OF CROSS PROTECTION.



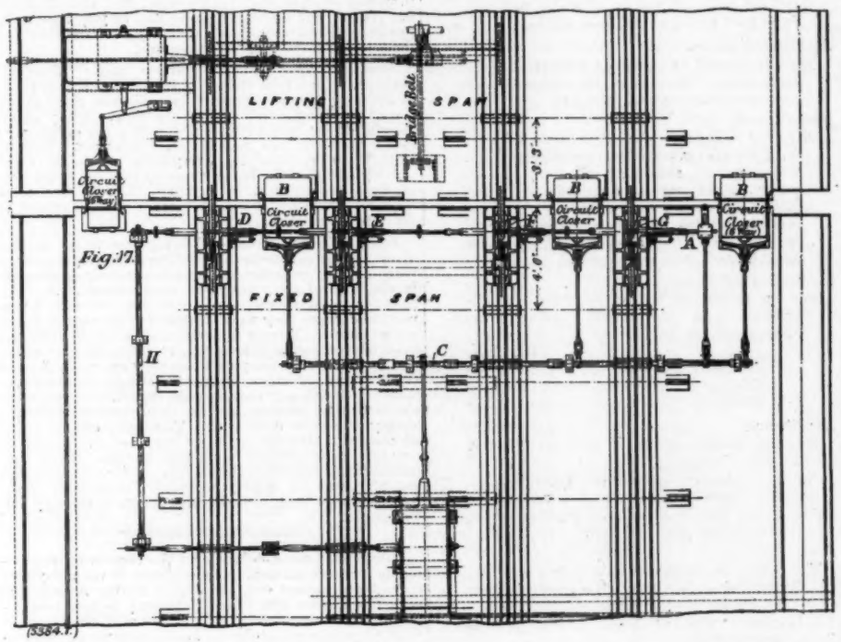


Fig. 17.

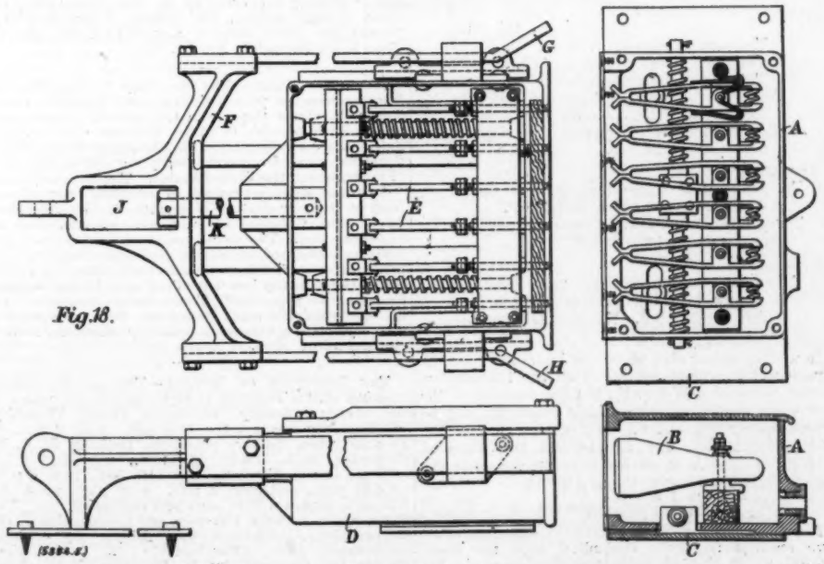


Fig. 18.

if required, can feed direct to the interlocking and track-circuit feeds.

The signal Z at Gunhouse end of the installation is supplied with current from a set of Fuller accumulators which are connected across the low-voltage mains; this battery consists of six cells, giving 12 volts, and has a capacity of 30 ampere-hours. The voltage of the mains at the point of connection of this battery is about 14, and through a variable resistance is continually on charge at a rate about equal to the output during 6 hours. This arrangement allows a circuit of 2.2 amperes for 10 seconds available for clearing the signals, without causing an excessive drop of potential in the feeds.

Wiring.—The operating and control wires are run in grooved trunking laid in the 6-ft. way where possible, to enable the sleepers to be removed without interfering with the wire run. Between the lifting span and the cabin flexible conductors are used, made up into cables protected by cab-tyre sheathing. These cables are so arranged that when the lifting span is down they are carried in troughs constructed of angle bars, and are lifted out in long and easy curves when the bridge is raised. The portions of the cables that have no movement are securely fastened to the bridge girder by means of substantial cleats. The wires on the fixed span are carried in wooden trunking with the exception of those portions of the cross runs which are carried through the rail-supporting timbers. In these cases lengths of 3-in. substantial iron tubes, bushed with fibre conduit, are used. For expansion at all points where necessary, trunking is allowed to move freely by sliding through boxes which contain the slack wire. All trunking over the fixed spans is carried upon wrought-iron brackets firmly secured to the structure by tapped bolts. Throughout the wiring care has been taken to avoid soldered joints, and to prevent slackening of terminal screws track-circuit connections are fitted with spring washers. Main feed and return wires are used to supply the track circuits with current from a central supply. These mains also supply current to the indicators, line and repeater relays, &c. Overhead wires carried on tall steel masts 110 ft. above high water of the Trent serve to connect the signalling and telephone circuits on each side of the river when the lifting span is raised.

The author would like to place on record his appreciation of the valuable assistance rendered by the company's signal superintendent, Mr. A. F. Bound, under whom the whole of the signalling installation controlling the railway and the working of the bridge was carried out; also of the services of Mr. E. C. Irving, the engineer of the British Pneumatic Railway Signal Company, Limited, the contractors for the work, for the care and attention given to the novel and intricate problems which were met with and successfully overcome in completing the work.

TRADE MARKS.—We are informed that the Trade Marks Committee of the Federation of British Industries has decided to oppose Part 2 of the proposed new Government Bill "To amend the Trades Marks Act, 1905," on the ground that it will inflict serious injury on the owners of perfectly legitimate trade marks. Part 2 deals with "Provisions for the Prevention of Abuses of Trade Marks." It has also been decided by the same committee that the proposed British Empire trade mark should be opposed.

NATIONAL UNION OF MANUFACTURERS.—With reference to the paragraph on page 126 *ante*, respecting the lecture given by Sir Herbert Austin, K.B.E., on February 4, entitled "A Few Remarks on Works Costs," we are informed that this lecture is being published in the *United Manufacturers' Journal*, which is the official organ of the union, and the hon. secretary will be pleased to send a copy to any of our readers who would like to possess one. Applications should be addressed to Mr. George Pike, care of Messrs. John Yates and Co., Limited, Aston, Birmingham.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has sent us a copy of a new Consolidating List (No. 46A) containing the names of over 3,500 persons and firms with whom persons in the United Kingdom are forbidden to trade under the Trading with the Enemy (Statutory List) Proclamation. It is important that everyone engaged in foreign trade should realise that he is under an obligation to make himself familiar with the Statutory List and to observe it in his dealings. Failure in this respect renders him liable to the heavy penalties provided by the Trading with the Enemy Acts, and these apply to holding any communication with anybody on the Statutory List and not merely to entering into an agreement or continuing to carry on business with such persons. In exceptional cases where it appears to be necessary and where it is not contrary to the public interest, a licence may be obtained from the Foreign Trade Department exempting from the prohibition. The Statutory List is published at intervals in a consolidated form, and additions are made approximately at intervals of a fortnight. Copies of the Consolidated List and of all additional lists may be obtained at a small cost from the Superintendent of Publications, His Majesty's Stationery Office, Imperial House, Kingsway, W.C. The additional lists are also printed as issued in *The London Gazette* and *The Board of Trade Journal*. Persons engaged in foreign trade should take steps to have access to one of these sources of information and should only rely on a trade journal if they have reason to know that it publishes the list in full.

BOILERS WITH AIR HEATERS.

FUEL economy is daily becoming a more urgent matter, especially in electric supply stations. The cost of fuel is there in many cases about four-fifths of the generating expenses, and one-half of the total costs, apart from interest, depreciation and redemption. Quite a small economy in coal may therefore amount to a large sum per annum, and engineers are seeking to effect all the saving that is possible. Naturally the auxiliary machines are subjected to keen scrutiny. It is well known that many of them in the past have been great steam eaters. On board ship great economies have been effected from time to time in this respect. The exhaust from pumps has been turned into the intermediate, or low-pressure, receiver, and into feed heaters, in the endeavour to utilise all the heat. In electric supply stations the pumps have been driven by electric motors, and more recently by small steam turbines. These latter, of course, use a great deal of steam, but all the residual heat has been conserved by turning the exhaust into the feed heaters and raising the feed to some 200 deg. F.

There has been considerable discussion in America as to whether, with the feed water so raised to 200 deg. F., it is profitable to put in a water economiser, or whether the gases escaping from the boilers should be allowed to pass to the chimney without any attempt to conserve any of the heat of those gases. This question of whether or not water economisers pay under such conditions is largely a question of cost of fuel per unit of heating value, which to-day is very much higher in Great Britain than it is in the United States. In this country, and in America where steam auxiliaries are employed to heat the feed water to 200 deg., it certainly pays to save a proportion of the heat of the escaping gases from the boiler by the employment of an air heater to preheat the air used for the combustion of the fuel, for by the use of such air heaters not only is heat conserved which would otherwise be wasted, but the preheated air improves the combustion of the fuel; especially is this the case where the fuels are low grade. Much experience of the value of heating air on its way to steam furnaces has been gained during past years, notably by Messrs. James Howden and Co., of Glasgow, who have fitted many hundreds of boilers, equipped in this way, in steamships and on land.

The progress of time and the requirements of special installations have, however, led to new designs adapted to meet the demands of stricter specifications. As an example of these we illustrate on page 230 the first unit, consisting of one pair of boilers with stokers and air heaters, about to be installed in the new generating station of the Northampton Electric Light and Power Company by the Underfeed Stoker Company, Limited, of Coventry House, South Place, London, E.C. 2. The rapid and continuous demand for electric power in the staple industry of Northampton has necessitated the erection of a new generating station on a much larger scale than it was possible to carry out on the existing site. Consequently a new site of about 8 acres was purchased, lying between the River Nene and Hardingstone Junction of the Midland Railway and London and North-Western Railway. Water for condensing will be obtained from the river, and the site has been connected with the junction by a railway siding. There is also an alternative route for coal traffic, as the river is connected with the Grand Junction Canal.

The new generating set now being installed, according to the designs of Mr. G. H. Jackson, the company's manager and engineer, is a British Thomson-Houston turbo alternator, 3,000 kw. capacity, running at 3,000 r.p.m., 6,600 volts, three-phase, 50 cycles. Two other smaller turbine sets are being removed from the present generating works. Future sets will be at least 5,000 kw. or 6,000 kw. capacity. In this installation there is one chimney for each four boilers, and the engraving shows two of these boilers, there being an air heater for each boiler. The air is supplied to the air heater through a duct leading from the main generator (Figs. 1 and 4) in such a way as to utilise the heat of the air from the generators. It is heated to a comparatively high temperature in passing through the air heater, and from thence to the suction inlet of the fans, from which fans it is discharged to the Underfeed Stoker Company's travelling grates. In this station the circulating pumps and the air pumps are to be steam driven, and the exhaust steam utilised for heating the feed water as described above. The arrangement is clearly shown in the engravings. The air heaters (Figs. 1, 2, 4 and 5) each comprise 36 elements, between which the hot gases of combustion flow from the boiler to the main flue. The warm air main from the generators is splayed out into 36 branches of inverted U-form. Each branch is further divided by a diaphragm (Fig. 4) to equalise the flow in the upper and lower portions. The total length of an element is 10 ft., and the depth 4 ft. 5 in., while the width of each heater chamber is 9 ft. 3 in. Below the heater there is a dust hopper, and above it there are cleaning doors.

The warm air is drawn into and through each heater by a fan driven by an electric motor. To guard against stoppages there are three motors for the two fans (Fig. 3). The air then rises into the air duct (Fig. 4), and flows through the travelling grate into the furnace; the resultant gases flow over the boiler heating surfaces and back between the elements of the air heater to the main flue.

The following extracts from the specification will show the extent and requirements of the plant:—

Boilers.

Number of boilers, 2.

Heating surface of each boiler, exclusive of superheater, 5,346 sq. ft.

Normal duty of each boiler, 21,000 lb. of water from feed water at 100 deg. F. at a pressure of 200 lb. per sq. in., superheated to a temperature of 650 deg. F.

Overload duty, 26,200 lb. of water per hour from feed water to steam as above.

Mechanical Stokers.

Each boiler will be equipped with two travelling grate, forced-draught stokers, each having a grate area of 72 sq. ft.

Fan Capacity.

Each fan is capable of delivering 22,500 cub. ft. of hot air against a total resistance of 3-in. water gauge, absorbing 20 brake horse-power. For normal duty of the boiler, 19,000 cub. ft. of hot air will be delivered per minute and the horse-power absorbed will be 13.5 brake horse-power. Air pressure in main duct, 2-in. water gauge.

Guaranteed Efficiency.

For the combined boilers, superheaters, air-heaters, and mechanical stokers, the efficiencies are as follow:

	Per Cent.
Efficiency, full load	80
Efficiency, three-quarter load	80
Efficiency, 25 per cent. overload	78

Air Heaters.

Heating surface of each air-heater boiler, 2,668 sq. ft.

Number of heater elements per boiler, 36.

Relation between air-heater heating surface and coal burned per hour, normal capacity, 0.8 sq. ft. per pound of coal.

Fuel.

The coal to be burned is as follows:—

Midland fine slack through a screen having holes $\frac{3}{4}$ in. in diameter.

Heating value as fired, 10,000 British thermal units.

Screening analysis:

	Per Cent.
Through $\frac{1}{16}$ diameter hole	37
Through $\frac{1}{8}$ diameter hole	25
Through $\frac{3}{16}$ diameter hole	26

Coal to be burned per hour per boiler for the normal duty, 3,325 lb.

Rate of combustion per square foot of grate, normal duty, 23.2 lb.

Temperatures.

The temperature of gases leaving the air heater and entering the chimney, 400 deg. F.

Temperature of air leaving the air heater and entering stokers, 230 deg. F.

Chimney.

The chimney is 110 ft. above grate level and is arranged to take the gases from four boilers as described. The internal diameter of chimney, 9 ft. 6 in.

It will be noted that while the guarantees for the capacity of the plant are based on the temperature of feed water at 100 deg. F., the temperature of the feed water under normal working conditions will be approximately 200 deg. F., after passing through the feed water heater, and the normal and overload evaporations will be increased in accordance with the increase in temperature of the feed water.

THE BRITISH FIRE PREVENTION COMMITTEE.—We have received from this Committee their red book, No. 214, which gives an illustrated description of a fire which occurred in a reinforced concrete warehouse, at Far Rockaway, New York. The building and its component parts, together with the results of the fire, are described in detail, and conclusions are arrived at both with reference to the fire-resisting value of the different concrete mixtures and to the various ways of carrying out a concrete construction. The committee, besides continuing their experiments, accounts of which we have given at various times, are collecting particulars from actual fires at home and abroad, where reinforced concrete structures have been affected, and the red book No. 214 in question deals with such a case.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The demand for finished and semi-finished steel continues at a very high level, and while outputs have, meantime, practically reached the maximum, the only way by which these could be added to would be by a better supply of pig-iron and scrap being forthcoming. Just at present, however, this seems impossible, therefore every available ton of material is apportioned out on a rigidly equitable basis to the consumers engaged either directly or indirectly on Government contracts. As a natural consequence this means that both the home and the overseas consumer who does not come under this category must stand aside until better industrial conditions rule once more, or some scheme of "rationing" be devised whereby their wants may at least in some measure be supplied. Steel bars of high tensile quality and every kind of sectional material and plates required for shipbuilding purposes are of first importance at the steel works, and the demand for these is as insistent as at any time since the outbreak of war. Various rumours are heard regarding proposed amalgamations in the steel, iron and engineering trades, but nothing definite has, as yet, been made public, so that developments are being awaited with much interest by more than a few persons.

Malleable Iron Trade.—Matters move along—or perhaps, rather, rush along—in the malleable iron trade, in the way to which makers have become quite accustomed now, and a rush it is all the time. Every mill is running to its fullest capacity and still the orders pour in for both the iron and the steel products. Nothing is left to accumulate, everything produced being quickly absorbed for home consumption, the small sizes of bars being much in demand. During the week "Crown" bars for the home market have advanced to 15*l.* 17*s.* 6*d.* per ton.

Scotch Pig-Iron Trade.—The pig-iron trade, as one of the essential war-time industries, is sorely put to it these days to keep the production as nearly as possible to the level of the consumers' requirements. As it is, however, most people have to be content with a proportion of what they want—otherwise the output would not go round. Transit difficulties are much in evidence, both for conveying billets, &c., to the producing works and for delivering the pigs when they are ready for the steel-makers and other consumers. Under these circumstances it is not easy to satisfy the demands of customers clamouring for supplies, and the claims of new applicants simply cannot be dealt with. The entire output being, of necessity, reserved for home purposes, practically no overseas shipments are being put through. Being controlled, home prices are stationary, but for export, figures run high, and are eagerly accepted if material be forthcoming—price being of little consequence if delivery can be assured.

JAPANESE CREWS.—Owing to the increasing requirements for more seamen, in consequence of the many new ships being turned out, the Japan Marine Association, says *The London and China Telegraph*, is now contemplating the establishment of a school with the object of training sailors and stokers. In this scheme the association is strongly supported by the three leading shipping firms of the country, the Nippon Yusen Kabushiki Kaisha, the Osaka Shoshen Kabushiki Kaisha and the Toyo Kisen Kabushiki Kaisha.

AMERICAN MINES.—The Secretary for the Interior has announced a plan for developing American mines. This will release ships from the mineral import trade and make it possible to utilise them for other cargoes. Ships are now employed in bringing from abroad 2,000,000 tons of minerals yearly for the manufacture of munitions in the United States. The Secretary said: "American mines are capable of supplying every mineral used in the manufacture of munitions. We, therefore, have asked Congress for a special appropriation for experimenting. The development of new deposits and better methods of extraction and the substitution of home materials will have the effect of making the United States permanently less dependent upon foreign supplies for essential minerals." The minerals mentioned are nitrates, sulphuric acid, manganese, flake graphite, tin, mercury, potash, tungsten, antimony, chromite, magnesite and mica.

THE INSTITUTE OF METALS.—The annual general meeting of this Institute is to be held in the rooms of the Chemical Society, Burlington House, Piccadilly, W. 1, on Wednesday, the 13th inst., from 8 p.m. to 10 p.m., when the new president, Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M., will deliver his address, and on Thursday, the 14th inst., from 4 p.m. to 6.30 p.m., and from 8 p.m. to 10 p.m., when the following papers will be read and discussed: (*a*) "The Relationship between Hardness and Constitution in the Copper rich Aluminium-Copper Alloys," by J. Neill Greenwood, M.Sc. (Manchester); (2) "Aluminium Bronze Die Casting," by H. Whitaker, M.Sc. (Manchester), and H. Rix (Manchester); (3) "On Grain Size," by G. H. Gulliver, D.Sc. (London); (4) "Lead-Tin-Antimony Alloys," by Owen Wm. Ellis, M.Sc. (London); (5) "An Investigation on Unsound Castings of Admiralty Bronze (88:10:2): Its Cause and the Remedy," by Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M. (London), and Miss C. F. Elam (London). The eighth annual May lecture will be given at the Institution of Civil Engineers, Great George-street Westminster, S.W. 1, on Thursday, May 2, 1918, at 8.30 p.m., by the Hon. Sir Charles Parsons, K.C.B., F.R.S., on the subject of "The Formation of Diamond."

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Benzol Plant.—In a highly interesting address, delivered on Saturday to the members of the Midland Section of the Coke Oven Managers' Association, held at Leeds University, Mr. W. Greaves, F.I.C., made special reference to the manufacture of concentrated ammonia liquor and benzol and the simplification of methods and plants. Describing a simplified way of manufacturing crude benzol, he said the benzol was extracted from the coal-gas by the usual method of scrubbing, but, instead of the benzolised oil being then brought into contact with live high-pressure steam in the ordinary form of benzol still, it was pumped under pressure through a cast-iron coil, and heated to a temperature of 145 deg. C. by hot furnace gases. The hot benzolised oil was sprayed into a small still or dephlegmator, the inside of which was at the atmospheric pressure. The benzol and water vapour pass away to a condenser and separator to divide the condensed water from the benzol, whilst the dehydrated and debenzolised oil flows to the oil coolers to be again used for absorbing a further quantity of benzol from the gas. In this way it was easy to produce the ordinary 55 per cent. crude benzol.

Henry Bessemer and Co., Limited.—Colonel Sir Charles Allen, presiding at the annual meeting, said the company was never in a sounder or more healthy condition. Reviewing the work of the year, he pointed out that both at Sheffield and Bolton the works had been fully employed during the year, and every ounce of their product had been practically used in assisting to win the war. The works had been maintained in a full state of efficiency, and they had endeavoured as far as possible to improve, to modernise, and to prepare for better times. The shortage of labour had been a source of difficulty, but still they had been able to keep the works in a thorough state of efficiency, and they had, so far as Sheffield was concerned, been able to effect some modernising of equipment which would not only assist them to produce more economically but to improve in every way the quality of their output. Bolton still continued to contribute handsomely towards their profits. As to the future, it might be considered foolish to try and anticipate what it contained, or to forecast what they might anticipate during the year. If they were curtailed in their output, the expenses would go up and the output would go down, and consequently there would be less profits. That, however, was only a forecast, and he hoped it would not be realised.

South Yorkshire Coal Trade.—The railway companies are taking on the top of their full quantities, whilst blast furnaces and converting furnaces are making bigger demands every week. Hards, cobbles and slacks are all going away on contract account. All three qualities are in heavy demand, particularly screened nuts, which are now heavily used by munition works, together with the better qualities of slack. The strain all round is great, and practically nothing is offered on contract account.

THE HANYANG IRON AND STEEL WORKS.—The steel output of the Hanyang Iron and Steel Works, China, in 1916, was as follows, according to the United States Consul-General, Hankow, reported in *The Iron Age:* Rail steel, 9,535 tons; mild steel, 33,568 tons. There were no additions to the Hanyang steel plants nor to the new plant at Tayeh. Salaries of the steel plant staff of 276 and of 2,000 workmen and 2,500 labourers were raised 5 per cent. in 1916.

LABOUR TURNOVER AND THE DISABLED WORKMAN.—What to do when a workman has been injured, in order to reduce labour turnover to a minimum, was discussed by E. B. Morgan, safety engineer of the Norton Company, Worcester, Mass., before the National Safety Congress at its last meeting, says *The Iron Age*. He urged close co-operation of the plant physician, the safety engineer and the employment manager, whereby the disposition of any injured employee's case is known at all times, and no delay is incurred or mistake made in placing him back on a wage-earning basis at the earliest moment consistent with quick recovery. Except for the malingerer, no difficulty is encountered in rating an injured man as to his future ability to earn a living. He urged that plans, based on the experience of safety engineering staffs or large industrial organisations, be formulated to deal with the approaching problem of the employment of disabled soldiers and sailors.

GLASS CUTTING TOOL.—In his laboratory the chemist cuts a glass tube or bottle which he wishes to crack in a particular direction with a diamond or a file, and then heats the glass immediately in front of the cut by means of a hot wire, which may be placed round the tube or of the heated end of the file, so that the crack, favoured by the sudden expansion of the glass or by its cooling again will proceed in the right direction. In the *Journal of the American Chemical Society* of September, 1917, Mr. Kenneth H. Parker describes a special tool for this purpose. The tool resembles a soldering iron, and is made of brass or copper. The hollow head of the tool is heated from inside. The head is pyramidal in shape and rounded off on the lower side so that its sharp point may well be applied to any particular spot. The head is screwed on to a tube which passes through the handle of the tool, and is joined by rubber tubing to a gaspipe. The gas escapes through perforations in the head, and is lighted, and the gas feed is so reduced then that the flame strikes back and burns at the nozzle in the head, making the head and point very hot.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron is quite plentiful, and if means of distribution are forthcoming March deliveries promise to be heavy. Though the truck shortage still gives grounds for anxiety, it is gratifying to learn that the situation shows improvement. Unfortunately, inadequate facilities for transport have again resulted in heavy arrears of delivery in February, and considerable allocations of foundry iron have had to be cancelled, as under the system allotments cannot be carried forward but have to be made or re-made from month to month. Further substantial forward inquiries on home account are reported for forge iron—a quality that does not come under the allocation system—but they do not result in sales of any consequence, producers still showing disinclination to commit themselves ahead. New foreign transactions are on a very limited scale, but shipments are going steadily forward to France through official channels, and exports to Italy are reported better. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are all quoted 114*s.*, and No. 1 is 119*s.*

Hematite Iron.—The East Coast hematite branch presents no fresh feature of moment. Restricted output is barely sufficient to meet present absolute home requirements, and consequently the quantity of iron available for sale to customers abroad is small indeed. Demand on behalf of the Allies is very pressing. Stringency may shortly be relieved to some extent by further increased use, for steel-making purposes, of iron manufactured from native ores. Mixed Nos. of hematite are 122*s.* 6*d.* for home use and 147*s.* 6*d.* for export to France and Italy.

Coke.—Coke continues in very good request both on home and foreign account, and values are well upheld, the plentiful supply having no apparent detrimental influence on quotations. Average blast-furnace kind is 33*s.* at the ovens, low phosphorus sort 35*s.* 6*d.* at the ovens, and foundry quality 38*s.* for home use. For shipment, the last-named description is 42*s.* 6*d.* f.o.b. to the Allies and 45*s.* f.o.b. to neutrals. Export price of gas-house coke is 38*s.* to 40*s.* f.o.b.

Manufactured Iron and Steel.—Little news is ascertainable concerning finished iron and steel. Demand is as insistent as ever, and great expansion of output has been accomplished, but production continues to be absorbed by the very large Government needs, and the demands of the shipyards. Production of shipbuilding material is now the prime necessity, and is enormous. Prices, all round, are strong. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.*; iron ship angles, 13*l.* 15*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Export quotations, though not fixed, approximately 40*s.* above home prices.

THE ROYAL SANITARY INSTITUTE.—The ordinary general meeting will be held at the Institute on Wednesday, April 24, at 4 p.m. On the same day, at 5 p.m., a discussion on "Housing: Planning and Materials, Permanent and Semi-permanent," will be opened by F. Baines, M.V.O., F.R.I.B.A., principal architect H.M. Office of Works; and on "Fitments and Conveniences," by Mrs. Sanderson Furniss, secretary of the Housing Sub-Committee, Women's Labour League. The Chair will be taken by Sir Henry Tanner, C.B., I.S.O., F.R.I.B.A. The Henry Saxon Snell prize in the year 1918 will consist of fifty guineas and the medal of the Institute, and is offered for an essay on "Suggestions for Improvements in Apparatus and Appliances for Dealing with House Refuse."

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: GLASGOW BRANCH.—Under the auspices of the Glasgow Branch a propaganda meeting was held on Thursday, 21st ult., in the Christian Institute, Motherwell, and was attended by a large number of draughtsmen employed in that district. Considerable interest was evinced in the work of the Association, and the meeting is likely to strengthen the support of the Motherwell draughtsmen. The quarterly general meeting of the members of the Glasgow branch was held in the Christian Institute, Bothwell Street, on Friday, the 22nd ult., and about 500 members were present. The general secretary attended and was officially welcomed by the members. A report of the progress of the branch was submitted by the local secretary, and proved highly satisfactory. Over 1,400 members had paid their subscriptions, and it was anticipated that the membership of the branch would reach 1,500 at an early date. The result of the referendum has shown a practically unanimous desire for registration as a trade union. The members were informed of the determination of the Manchester Conference and the probable effect of these on the future trend of the Association. Auditors were appointed to examine the books, and reports were submitted by the conveners of the sub-committees. The meeting was highly successful, and the appreciation of the members was shown in the hearty vote of thanks which was accorded to the office bearers.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—In regard to the pre-May contract arrears interested parties have been asked to send particulars of their cases by March 4, when the Contract Arrears Committee will meet for the first time to deal with them. The contracts concerned are stated to be numerous, and it is already computed that the settlement of the outstanding difficulties will occupy the committee for at least twelve months. Pitwood supplies are scarce, and difficulties have arisen in regard to delivery owing, it is maintained, to the unremunerativeness of the maximum price of 65*s.* per ton at the pit-head for home-grown supplies. Contractors complain that the maximum price does not take into account the heavy cost of transport from port to colliery, and in the case of Irish wood a demand is being made that the 65*s.* should be the price ex-ship and not at the collieries.

Newport.—Employment in both the Eastern and Western Valleys of Monmouthshire this week has been very irregular, and fears are entertained of extended stoppages. An official announcement is now expected with regard to the progress of the allocation scheme, and it is understood that it is the intention of the authorities to put the scheme into operation immediately it has been officially sanctioned. Meanwhile inquiries are being made from collieries for the information necessary for the purposes of the Allocation Committee.

Allocation of Coal Orders.—Mr. Finlay A. Gibson yesterday made an interesting statement relative to the question of the more equal distribution of work throughout the South Wales coalfield. He explains that the Commission of Inquiry appointed to investigate the question of short time working promptly acted on the instructions of the Coal Controller, and after hearing evidence from a number of colliery companies the Commission arrived unanimously at a decision to recommend that there should be an allocation among the collieries of orders for coal for shipment to foreign destinations. Subsequently the Controller communicated with the owners' representatives on the Conciliation Board with regard to a proposal which had been made by the workmen's representatives in favour of the institution of a five-day working week as an expedient for securing more regular work at the collieries. The owners' representatives replied that they considered the desired object could better be obtained by other means, and they supported the recommendation in favour of allocation which had been submitted to the Controller by the Commission of Inquiry. The Controller thereupon instructed the Coal and Coke Supplies Committee to prepare immediately a scheme on the lines suggested by the Commission, and a final draft of the scheme has now been forwarded to the Controller of Coal Mines. Meanwhile, arrangements have also been made to obtain from the colliery companies the information required for the purposes of the scheme in order that there may be no loss of time. It is important to add, remarks Mr. Gibson, that the Commission of Inquiry have also considered the proposed scheme, and have forwarded to the Controller a unanimous report approving its principles, and expressing the view that it will probably bring about the desired results of a more equal distribution of trade, and, consequently, more regular employment throughout the coalfield.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.—The twenty-third annual general and other business meeting of this association is to be held at the Town Hall, Manchester, on June 20 and 21. A presidential address will be delivered by Mr. S. J. Watson, borough electrical engineer, Bury. There will be a discussion on "The Future of Electric Power Supply," and visits to works in Manchester.

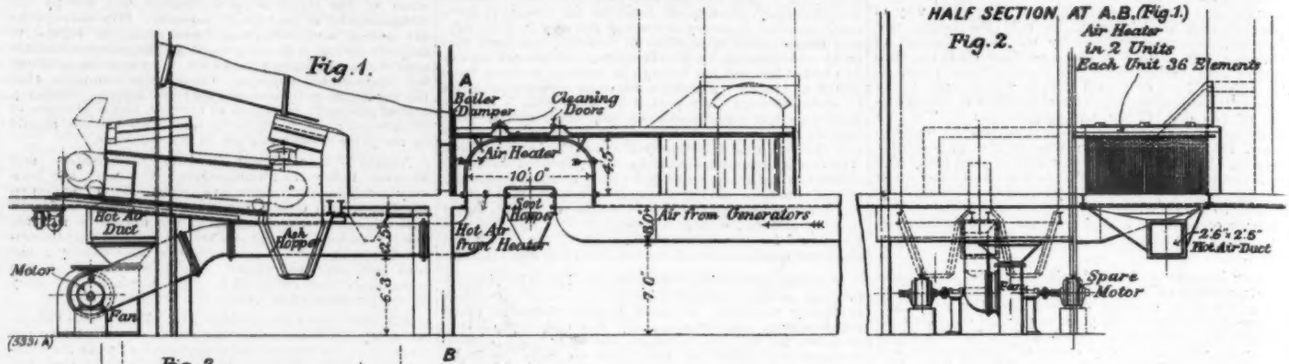
ALLEN WEST ENGINEERING SOCIETY.—The usual fortnightly meeting of the above society was held on Tuesday, February 19, at Brighton, when a paper was read by Mr. F. G. Smith, joint managing director of Messrs. Wellman, Seaver and Head, Limited, entitled "Steel Works Charging Machinery." The speaker dealt very fully with the design and construction of various types of charging machines; he showed the service to which these machines were subjected, and the operations each individual motor and controller was called upon to do.

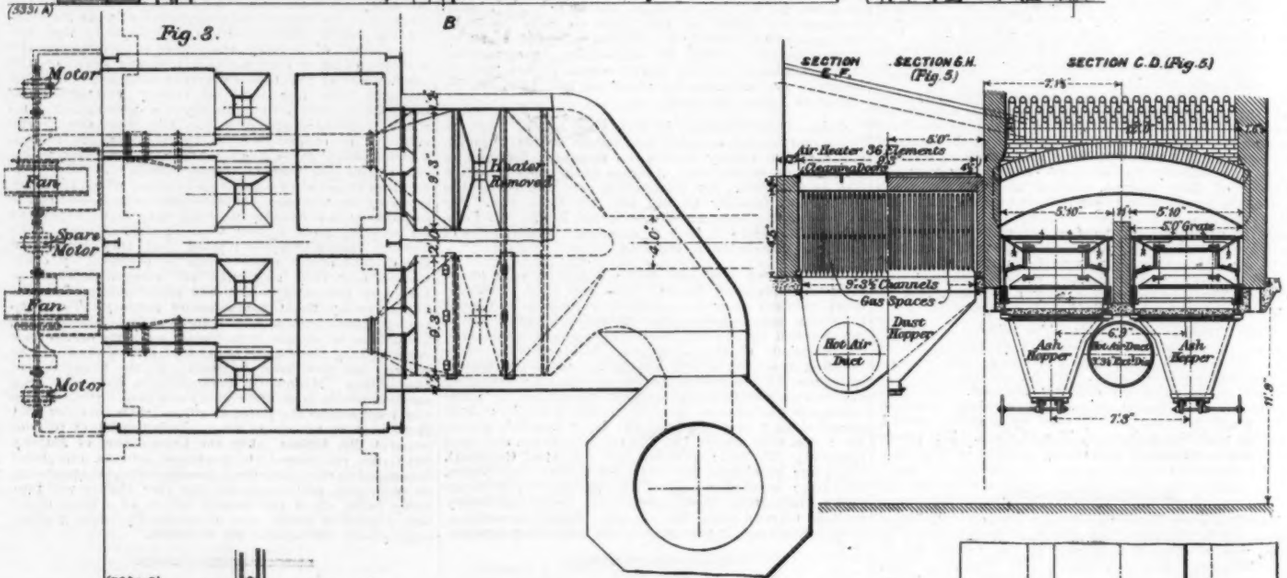
GLASGOW TRAMWAY ACCIDENT.—The Railway Department, Board of Trade, have issued their report, dated January 7, on the tramway accident which occurred at about 6 p.m. on December 5 last, in Victoria Road, when the car No. 157 left the rails and overturned. The motorman entered the service of the Glasgow tramways on September 4, 1917, at the age of sixteen years and two months. On December 1 he completed his probation and became a fully qualified motorman. The Board of Trade found that the accident was caused by too high a speed on a sharp curve, and that the misapplication of the mechanical brake was a factor. There was direct evidence to show that the motorman was not driving at a reckless speed whilst approaching the curve; his failure to reduce speed within safe limits before entering the curve was due to the lighting at the spot being insufficient to gauge the real position of the curve, and possibly, also, to some want of concentration on his own part. The Board of Trade recommended that lads should not be appointed as drivers under the age of 18. Those now employed should be kept on probation for at least three months; their hours of duty should be shortened, and more frequent holidays granted, until they reach the age of 18 years.

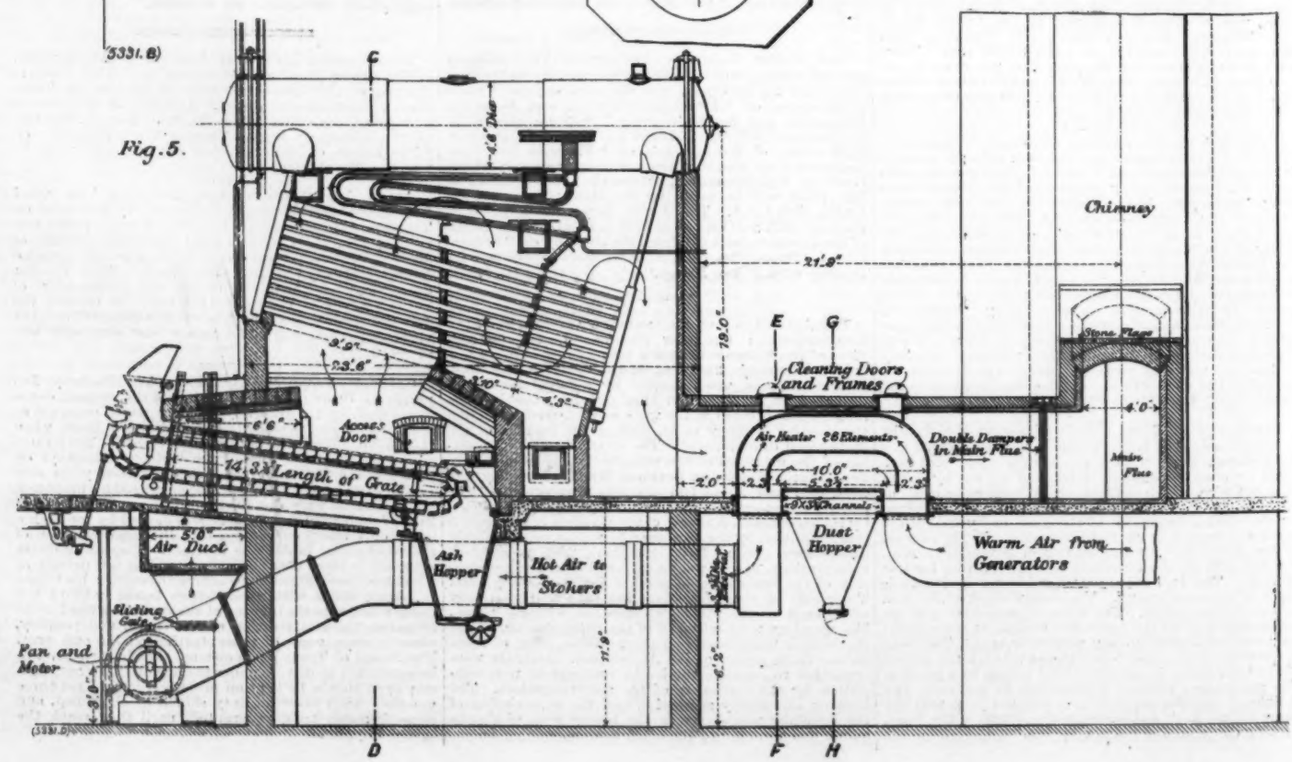
"USCO" AIR HEATERS AND TRAVELLING GRATE STOKERS.

CONSTRUCTED BY THE UNDERFEED STOKER COMPANY, LIMITED, ENGINEERS, LONDON.

(For Description, see Page 228.)







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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8568 GERRARD.

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NOTICES OF MEETINGS.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.—Saturday, March 2, at 7 p.m., at Cannon Street Hotel, London, E.C. "Painting and Wood Finishing from the Engineer's Standpoint," by Mr. A. S. Jennings, F.I.B.D.

THE ROYAL SOCIETY OF ARTS.—Monday, March 4, at 4.30 p.m. Cantor Lecture.—"The Effect of the War on the Economic Condition of the United Kingdom," by Mr. Edgar Crammond, F.S.S., Secretary of the Liverpool Stock Exchange. Lecture III.—"The Real Cost of the War and the Problem of Economic Reconstruction." Tuesday, March 5, at 4.30 p.m. Colonial Section.—"Portugal as a Colonial Power," by Mr. George Young, M.V.O., Ex-Secretary of Legation, Lisbon. Wednesday, March 6, at 4.30 p.m. Ordinary meeting.—"The Foundation of Industrial Peace," by Mr. A. H. Paterson, Secretary, National Alliance of Employers and Employed. The Right Hon. Frederick Huth Jackson, M.A., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 5, at 5.30 p.m. Paper to be submitted for discussion:—"Modern Developments in Gasworks Construction and Practice," by Mr. Alwyne Meade, Assoc.M.Inst.C.E. And ballot for new members.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 7, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster, S.W. "The Control of Large Amounts of Power," by Mr. B. B. Wedmore, Member.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 6, at 8 p.m., at the Royal Institution, Colquitt Street, when a paper will be read, which has been prepared by Mr. J. F. Ramsbotham, M.Inst.C.E., M.Am.Soc.C.E., entitled "The Lighting of the Great Barrier Reef North of Cooktown, Queensland." This paper is in substitution of that previously announced on "Cooling Towers as Applied to Large Power Stations," by Mr. W. Holehouse, who, owing to illness, is unfortunately unable to give his paper.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, March 7, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1. The following papers will be submitted for discussion:—"The Application of Charcoal to the Precipitation of Gold from its Solution in Cyanide," by Mr. H. E. Edmands, Associate. "Blast-Furnace Smelting of Stibnite, with Considerations on the Metallurgy of Antimony," by Mr. W. R. Schoeller, Associate. "A 'Responsive' Shaft Signal Device," by Mr. B. Angwin, Member.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: NEWCASTLE BRANCH; TECHNICAL SECTION.—Friday, March 8, at 7.30 p.m., in the Connaught Hall, Newcastle-on-Tyne. A paper will be read by Mr. R. A. Graveson, on "Propeller Design."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 8, at 5.30 p.m. A discourse will be delivered by Professor Edwin H. Barton, D.Sc., F.R.S. The subject will be "Vibrations: Mechanical, Musical and Electrical." Afternoon lectures next week at 3 p.m. Tuesday, March 5. Sir Richard T. Glazebrook, C.B., D.Sc., F.R.S., Director, National Physical Laboratory, on "A National Proving House and Standardising Laboratory" (Lecture II). Thursday, March 7. Sir Alexander Mackenzie, Mus.Doc., D.C.L., LL.D., Principal of the Royal Academy of Music, on "War Music: Past and Present" (with musical illustrations) (Lecture I). Saturday, March 9. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Professor of Natural Philosophy, Royal Institution, on "Problems in Atomic Structure" (Lecture IV).

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, MARCH 1, 1918.

THE DEFINITIONS OF SKILLED, SEMI-SKILLED AND UNSKILLED MEN.

A CORRESPONDENT whose letter is printed in another column urges that it is now desirable to obtain agreed definitions of skilled, semi-skilled and unskilled men, and gives a thoughtful and interesting description of what he understands to be the characters of these several classes. He puts this description forward not as a necessary definition, but as a basis on which one might be framed if it were not thought to be contained sufficiently in his own description. The question is well worth consideration, and perhaps our readers may have something to say on it. Beyond doubt, if the terms continue to be used, the time is opportune for arriving at a common understanding as to their meaning.

The course of industry, and in particular of engineering manufacture, is taking a turn that will require these terms to bear new meanings, if they are to be serviceable and not misleading. A solitary man practising a trade does not become a fully-qualified tradesman until he is master of every part of it. Our correspondent's intention is apparently to reserve the title of skilled to men who in this sense are qualified tradesmen. Part of the proposed test is that the man shall have served an apprenticeship to the trade. If this is to be a necessary part of a skilled man's credentials, as engineers will probably agree that it must be, the nature and extent of apprenticeship should be more strictly defined than it is at present, and perhaps—though this may be more questionable—some certificate should be required of the man's proficiency at the end of his time. Notoriously an apprenticeship in the shops may be very largely wasted. Apart from the disposition of some lads to slack and of some shops to tolerate slacking, an apprentice is often regarded merely as an item of cheap labour, which is used to the best advantage by being kept on the fewest possible jobs. An apprentice who has served his time under any of these conditions is not likely at the end of it to have the general proficiency of a tradesman; and while apprenticeships may be so served, some test is necessary if the men that such training produces are not to be regarded as fully qualified.

At the same time the better way, to which fortunately public opinion may now be inclined, is to make such stunted apprenticeships impossible. From a merely economical point of view they are as thriftless as the eating of seed potatoes; while from the lads' point of view they are an uncivilised outrage not the less to be condemned because it may often be perpetrated through mere lack of thought. Whatever arrangements may become usual in the training of workmen, it is to be hoped that they may be such as to allow the serving of an apprenticeship to be, as our correspondent assumes that it is, a sufficient warranty of his qualification as a tradesman. Whether it is desirable to require also that to be rated as skilled a man should have worked at his trade continuously since he came out of his time, is perhaps more open to question. It is possible for a man to be skilled at more than one trade; and in dealing with epochs of bad trade the difficulty of securing continuous employment is increased considerably by the practice of tying a man down to a single occupation, and compelling him to be idle when trade is bad in his particular line, though other work may be waiting for him if he is qualified and allowed to take it. One of the risks to which capital is most sensitive is that, when it has been sunk in plant for one class of work, the plant may not be convertible to another purpose. A workman's capital ability is his; and without wishing any man to be jack of all trades and master of none, it may still be felt that many men can acquire and practise a second trade without losing their fitness for employment in the first.

It must be observed, however, that if the standard of skill required in a skilled man is to include the serving of a really effective apprenticeship and the attainment of an all-round proficiency, the large majority of men in the engineering trades who now are rated as skilled will cease to be so. In a machine shop, for instance, a man is rated as skilled who is able to operate a particular kind of machine. He can obtain employment as a skilled man if he can operate a milling or a planing or a grinding machine. The experience of the war has shown, however, that in a properly organised shop he—or she—can learn that much in the course of a few weeks or a few months; and to include what can be acquired so readily in the same category as what demands a five or seven years' apprenticeship would be to detract seriously from the value to be attached to the rating of a fully trained man. Doubtless a man who, without help, could operate equally well not one but any type of universal milling machine on any class of work, setting up his own work and grinding his own cutters correctly, would be likely also to be skilled in the wider sense; but his title would be due in part to his training as an all-round mechanic, without which he would not have got his versatility on the special machine to which he was devoting himself. Moreover, there is a growing tendency in all good manufacturing shops, except the very smallest, to take

work such as grinding cutters out of the hands of the man who operates the tool, and give it over to the tool-room; so that a miller's ability to grind his own cutters would be a dormant talent.

It is, indeed, necessary to recognise that engineering manufacture, addressing itself as it does more and more to intensive methods, is making less and less use of all-round skill in manual workers. The constantly increasing subdivision of work that is known to be essential to economical production makes less demand for such skill than older methods made, and brings the great bulk of manual operations within the scope of semi-skilled or sometimes of unskilled labour, if it is directed with sufficient circumstance and detail. All-round skill may still be an advantage to the man who possesses it, even while he remains a manual worker, because it enables him to get employment at any sort of job in which work may be offered. But to a well-staffed and well-organised manufacturing shop all-round skill in manual workers is now of minor importance, because the all-round knowledge of the directional staff enables most of the manual work to be done by men of a rapidly-acquired single skill. Some operations there are that need so much dexterity of hand and eye as to be beyond the ability of an improvised operator, however well he may be taught, or even to require something like a natural genius for accurate work; such, for instance, as some of the finest optical fitting. Other arts, again, seem able to be taught by no form of words or directions without a prolonged experience corresponding to that by which the teacher himself acquired them; steel-melting is probably a good example of this class of work. Other work, again, like that of the millwright or the ship's engineer, depends essentially on the ability to cope with emergencies, and obviously cannot be trusted to men without a considerable variety of knowledge and skill. But in the bulk of manufacturing operations jobs can be broken up into portions so definite and manageable that little previous training is required for doing them; and for economical reasons the bulk of manufacture will therefore have to be conducted in this way in the future, whether it likes it or not.

The change has by now come to be a familiar prospect; and at first sight it seems to deprive the workman of the zest in his work that the skilled craftsman used to enjoy. This plausible view has unfortunately been caught up by those whose tastes or ambitions thrive on fomenting dissensions between class and class. Men have been warned by those who should know better—or if they have not the means of knowing better, should have had the self-restraint not to discuss matters of which they are ignorant—that under the system of intensive manufacture workers will become mere cogs in the industrial machine, set to monotonous drudgery, deprived of any source of interest in their proper work, condemned to labour without the dignity and self-respect that labour should bring. If this were a true statement of the position, it would be all the graver because there seems to be no alternative between accepting the methods so stigmatised and submitting to an inefficient production that industry cannot now afford. It may be worth while, therefore, to point out how this view is supported by a superficial consideration of the facts, and how completely it is contradicted by a more thorough examination.

There is the less difficulty in admitting that superficially the modern methods of subdividing work impose an element of increased monotony on the individual worker, because this has been the continuous tendency of manufacture since a man ceased to work by himself in his own home, and to make for himself both his tools and the finished product. Each stage of the primitive outright production had its necessary difficulties, and to overcome them as they arose gave the craftsman an inevitable variety of work, just as to have himself done every stroke of work on the job from the raw material to the finished article gave him a personal pride and interest in the product. What is now happening in manufacture merely continues the process that has been going on since men began to subdivide labour. At every step the worker has got more work done on his job by other men before he touches it, or has passed it on to another worker after he has himself done less. The intensive manufacture now in prospect differs, however, from the processes of natural subdivision by which manufacture has developed in the fact that in the past subdivision has been mainly an incident of the development, while now it is being sought as an end in itself to the utmost extent to which it can be carried economically. Not incidentally, but by direct purpose, the difficulties that individual workmen had formerly to overcome for themselves are being taken away from them and grouped, to be dealt with by others who have no other function. Even more generally and intentionally the day's work of each man is confined to doing as nearly as possible a single operation, and the time formerly spent in changing over is saved. Clearly such suppression of variety in the day's work involves an increase in its monotony; and if this were the whole story of intensive manufacture, the allegation that it increases monotony and reduces zest would often be unquestionably true.

But in fact such a description is quite incomplete. The charge against intensive manufacture lies as much as anything in the fact that it proceeds with the malignant thoroughness of a system, just as skimmed milk from a centrifugal separator is held to be and doubtless is a leaner product than hand-skimmed. The description just given, which contains in effect the grounds on which the new practice is charged with increasing the monotony of men's lives and depriving them of the dignity and self-respect that should be associated with labour, defines indeed the means by which manufacture is made more efficient, but omits altogether the conditions that any system must introduce, if it is to be successful. If these conditions are considered, it will be seen that they should assure a greater variety of occupation to every worker who desires it, a better chance of cultivating his dignity and self-respect, increased opportunities of advancing in his trade; in a word, a life so much better than has been possible hitherto as to outbalance by far the superficial monotony of a man's occupation at any particular time.

The whole purpose of intensive manufacture is efficient production. This involves in practice getting the most work done in a given time, partly because it has been found that only so can the most work be obtained per unit of effort, and partly in order to reduce the burden of dead work to the minimum. Thus an essential condition of the method is that men shall work at their best possible speed; and, on the common experience of every form of physical activity, working at top speed has an interest of its own, and an extraordinary effect in counteracting the sense of monotony. The absence of variety in the day's work is thus to some extent, and often wholly, offset by the constant interest in maintaining speed. In any sound system this interest is stimulated by the incentive of increased earnings; but though this incentive may be necessary to the best result, it is aided in any healthy and rightminded worker by the zest that is inherent in high-speed activities. Doubtless some workers may become stale after they have been long enough on a particular job, though as a fact some are quite insensitive to the monotony of the repetition so long as the interest in output is maintained. Such staleness is merely the physical expression of the sense of monotony, and indeed is a fair test of its existence. It is disadvantageous to the works as well as unpleasant to the worker; and in the interest of both it is to be remedied quite simply by transferring the worker on to a different job.

But a still more constant condition of working at top speed does even more to relieve monotony and improve the whole life of the worker. Top speed cannot be kept up for as long as moderate speed; and beyond any possible doubt intensive working means shorter hours and longer leisure. A man who spends some eleven hours a day in and about the works, with perhaps a couple of hours more spent in travelling, has little left of his days to number that he may apply his heart to wisdom. A couple of hours extra makes all the difference to the value of each day's leisure. On hours of work that are usual to-day a man's leisure hardly has begun before it has come to an end, if he is to have his proper allowance of sleep. It is only by an effort that it can be made enough for any useful purpose; and for many men it is little more than a preparation for bed. With two hours extra added, it becomes a sensible quantity, fit to be used with effect in whatever may best promote his enjoyment of life, able if used rightly to give him in all ways a better life than before. This increase of leisure is not a concession to be wrung by a mighty proletariat from a grudging capitalism. It is the direct and indispensable economic consequence of intensive manufacture; and incidentally, though the remark is a little wide of the present subject, it may be observed that a chief problem of reconstruction should be to provide an education by which ordinary and inconspicuous workers, the vast majority of the industrial population, may be fitted to make the most of the leisure by which their lives will be enriched and their energy augmented.

For most workers the provisions necessary for intensive manufacture will thus be more than sufficient to counterbalance what monotony it may add. Some, however, possessed of greater abilities than the majority, will still find their occupation insufficient for their powers. There are many such under existing methods; and the difference between future methods of manufacture and those that have prevailed hitherto is that intensive methods require about double the number of directional posts, in which those who are able to fill them may escape what monotony there may be in manufacturing operations, and attain a promotion that will benefit both the works and themselves.

When all these considerations are put together, it will be seen that, if the large majority of work that in the past was done by men who passed for fully-qualified tradesmen is in the future to be open to men of shorter training and more limited skill, the result should be an all-round upgrading of engineering workers. It is possible that the right solution of ratings in engineering shops may be similarly to upgrade the titles. It is almost as unsatisfactory that an efficient operator on a single class of work or a single machine should be described as semi-skilled as that on the strength of such a qualification he should be ranked with men of all-round skill and experience. It might perhaps be found most convenient to recognise the worker of all-round training and qualification by some title such as mechanic or tradesman, and allow the title of skilled to workers of a single skill. The style of semi-skilled, if it is thought desirable to retain it, would be reserved for those who in operating a single machine or performing a single operation need either skilled supervision or automatic mechanical control. This rating, however, though it may have been useful for war purposes, would perhaps be out of place in normal times, at least for the purposes of intensive manufacture. A semi-skilled man ought in a well-regulated manufacturing shop either to be converted into what on the qualification here proposed would be a skilled man, or else to be reduced to unskilled until some other operation can be found for him at which he is able to become skilled. This process should take so short a time that it may perhaps be thought needless to perpetuate the disparaging and unsatisfactory rating of semi-skilled. In shops engaged on intensive manufacture the advantage of this alteration in ratings would, no doubt, be mainly sentimental. In those, however, where intensive manufacture is less practicable it would serve also the material purpose of distinguishing more sharply differences in grades of experience and ability that at present are lumped together under the general title of skilled man.

A NEW BRITISH OIL INDUSTRY.

AT the beginning of 1916 the Institution of Petroleum Technologists appointed two committees, the one to investigate the desulphurisation of oil from Dorsetshire shale, the other to investigate the supplies of all materials in this country from which oil can be obtained by distillation. The latter committee reported that much material now

neglected or treated as waste could be utilised for the purpose. Government departments were then formed to inquire into the whole problem and to produce oil as speedily as possible, and good research work has certainly been accomplished. As no oil industry from new indigenous sources has been started, however, the Institution is anxious to show what must be done to develop such an industry and to avert the threatening oil famine. The joint paper on "A New British Oil Industry," which was discussed by the Institution on Tuesday, February 19, at 8 p.m., in the Royal Society of Arts, was drawn up with these aims by Messrs. Cunningham Craig, F. M. Perkin, A. G. V. Berry, and A. E. Dunstan.

Dealing with the general aspects of the problems, Mr. Cunningham Craig pointed out that oil could be obtained in this country by distillation from six sources. Only the first of these sources, oil shales, was being utilised in Scotland, whilst the Kimmeridge shales of Dorset and Norfolk were hardly worked commercially, in spite of strenuous efforts. Before the war about 3,250,000 tons of shale oil were mined in Scotland, yielding 320,000 tons of oil; the distillation was conducted at relatively high temperature to secure a maximum of ammonium sulphate and paraffin wax. Of three other sources, coal yielded too little liquid fuel, lignite was not yet developed, and peat too troublesome. There remained as available sources cannel coal and torbanite, and, lastly, blackband ironstone. Cannel coal was less easily carbonised than ordinary bituminous coal, contained more hydrogen, and was jetonised with specks of spores. Torbanites resembled cannel coal; they were not by any means confined to the Torbanehill mineral of Bathgate, but occurred in many British coalfields. They consisted of a coal matrix in which were embedded yellow or brown bodies, oval or irregular, known as kerogen, according to Mr. Craig's own studies apparently chemical combinations of hydrocarbons of organic origin with inorganic matter. The kerogen globules seemed to undergo a degeneration in four stages and the torbanite preserved a half-way stage between the carbonaceous and petroliferous phases; where in coal measures torbanites were frequent in the upper members, seepages of crude petroleum were prominent in the lower strata. Though different, cannels and torbanites were inextricably mixed up. Cannels rarely occurred in seams of more than 3 ft. thickness, and many bastard cannels and canneloid bands were left below or accumulated on waste heaps as inferior fuel, too rich in ash, though they would yield oil by distillation from their kerogen and uncarbonised vegetable matter.

In the blackband ironstones iron hydrate and carbonaceous matter, in the kerogenous, slightly carbonised condition, were intimately associated, and often accompanied by cannel seams. The famous black bands were already exhausted; the plentiful thin seams were, as far as worked at all, fired in open bings creating a nuisance and wasting the oil, though yielding a good oxide for the blast furnace. Mr. D. V. Hollingworth had recently demonstrated on a small but practical scale that oil could be extracted by distillation of ironstone, and that by retorting at suitable temperatures enough gas could be produced to make the process self-supporting, the products being some ammonium sulphate and "carbous iron," an iron oxide with fixed carbon considered economically and generally superior for the blast furnace. On some such lines a new industry might be based upon these cannels and blackband ironstones. It would have to be a low-temperature carbonisation, more productive of oils than of ammonium. But a compromise could be effected by adapting the process to conditions. It might be inadvisable to treat cannels yielding less than 25 gallons of oil per ton of coal; the ironstones would be less productive still, but something like 35 gallons might be secured on average, whilst Scottish shale oils gave 22 gallons of crude oil and 42 lb. of ammonium sulphate per ton. The cannel raw material might cost 7*s.* and more per ton to mine and to bring to the retorts, against 5*s.* 6*d.* for oil shales On the other hand, the shale oils left enormous residues on waste heaps, whilst the cannel residue might be worked into briquettes after being utilised in producers for gas and ammonia. The suggestion had been criticised; but there was promise in it, if worked on a larger scale in central works, of which six might certainly be established. Of the fifty odd shale companies started in Scotland only five had survived; but they paid good dividends.

The three other authors referred particularly to the vexed question of high or low-temperature carbonisation, which does not appear to get past the experimental stage. The benzol, toluol, carbolic acid, &c., wanted for explosives and dyes, Dr. F. Mollwo Perkin stated, were high-temperature products; the fuel oils, the creosote oil of the gas works, low-temperature products. More tar could be obtained in the gas works by lowering the retort temperature or by passing steam up the vertical retorts. But then less gas was produced and less coal put through the retort daily. Supervising some experiments in vertical retorts on the Glover-West system for the Nitrogen Products and Carbide Co. recently, Dr. Perkin had found that, at 1,411 deg. C. 4.2 tons of coal passed through the retort in 24 hours, and at 1,194 deg. only 2.6 tons; the tar was increased, but less coal carbonised and less gas obtained. Steaming gave more tar and more gas, but the tar was poor in benzol and difficult to purify of aliphatic compounds. Dr. Perkin added figures concerning various coals (bituminous, slack, cannel) to show that from 20 gallons to 40 gallons of crude oil could generally be expected from low-temperature carbonisation of a ton of coal. The Government had rather handicapped the raising of money for the oil industries, however. Cannel coal was not suitable for gas works and domestic use; but the oil production might prove as advantageous as the ammonia production from oil shales had been.

Mr. A. G. V. Berry and Dr. A. E. Dunstan, in their joint contribution, dwelt on the sampling and testing and on the products of retorting of cannel coal. The work so far done on that coal had mainly been in the interests of gas-making and not of tar-producing. It was true that this low-temperature tar contained little naphthalene and anthracene, considerable amounts of paraffin, and little benzene, &c.; but the proportions were largely a question of temperature, the methyl esters produced would be valuable as germicides, and the paraffins might be hydrogenised after desulphurisation. The crude oil from the cannel coal would, as a Navy fuel, have to be refined to cut out the solid paraffin; at the same time some light motor fuel would be gained. The removal of paraffins of relatively high setting-point could be effected in two ways, either by routine refining, when the paraffins would be recovered, or by cracking, when part of the paraffins would be destroyed; the latter method had its disadvantages, but also the advantage that no refrigeration process would be required.

If the papers—of which the chairman, Mr. Charles Greenway, gave a brief abstract—were optimistic, the lively discussion, though on the whole very favourable, did not fail to draw attention to weak points of the suggestions. Mr. Hill and Professor Cadman pointed out that the industry would not be new; distillation of cannel coal for oil had been thriving in Staffordshire until the competition of the Scottish shale oils and from abroad, and the cost of materials had stifled it; the records of British rock oil went back to the seventeenth century, and A. Gessner had, in 1845, already described vertical and revolving retorts. But the industry is new in the modern sense, of course, in which the authors meant it. Whether the raw materials will prove as plentiful and inexpensive, the utilisation of the briquetted residues and of the ironstone oxide from retorts as easy as claimed, and the technical and financial difficulties reasonable—as to those questions most people will welcome the chairman's statement that the whole problem would be submitted to a committee comprising colliery owners and financial men. But Sir Boverton Redwood, Sir Lionel Phillips and others confirmed the high fuel-oil yields (up to 120 gallons per ton) from cannels. Mr. A. E. M. Taylor stated, on behalf of Nottingham colliery owners, that they were ready to find half the capital for erecting low-temperature retorts and a refinery, provided the capacity were for 10,000 tons daily, whilst Mr. Todd said that colliers wished first to be reassured about official financial interference. If low-temperature coal distillation were not still in the experimental stage over here, the scheme would look less venturesome. The new industry will certainly make heavy demands on money, technical skill and time; but that would be so with the building of tankships, which would leave the country dependent upon other countries for indispensable needs, while the days of piling up waste heaps ought to be past.

THE LATE EARL BRASSEY, G.C.B.

By the widely regretted death, in his eighty-third year, of Earl Brassey, which occurred on the 23rd ult., at his residence, Park Lane, London, there has passed away one who, for more than half a century, fulfilled an important part in the evolution of the maritime greatness of the Empire. The son of the head of a firm of contractors for public works—who lives in the memory of engineers not only as a man of great originative and organising capacity and of sterling worth, but of broad views on the subject of the relation between employer and employed—the late Earl owed much to heredity. Notwithstanding that his father left him a wealthy man, he displayed, up to the end of his long life, a remarkable activity, and every scheme for the advancement of imperial interests found in him a ready advocate, forceful and convincing both in the written and the spoken word, and an enthusiastic worker of great vitality. It was natural that he should be interested in industrial and labour problems, and in his many books on the subject he advocated that consideration for labour which is only to-day being fully recognised not only as a right to the worker but as a necessity to increased production, and therefore to improved national welfare. Skimming through some of his earlier books, one recognises now the farsightedness of his attitude, and the correctness of his enunciation of the principles of industrial economics.

We are concerned here, however, more with his work for the Navy, shipbuilding and engineering. Early in life he developed a love for the sea. His yachting was not a mere means of enjoying leisure, but a full reality, as he studied and became proficient in practically every department of ship management. He was the first of the so-called amateur yachtsmen to pass the examinations for the Board of Trade certificates for shipmasters; this was in 1872. No days of his life were so full of genuine enjoyment as those spent in navigating the Sunbeam, which, before being handed over by his lordship to the Indian Government as a hospital ship, had traversed 400,000 nautical miles. It was characteristic of his wide interests, too, that in all these voyagings, on every sea, he collected rich and rare treasures, with the result that the "museum" in his house at Park Lane became a storehouse of immense interest. An inspection added greatly to the pleasure of those to whom his hospitable doors were open, these including nearly all the technical institutions at one time or another. This pleasure was enhanced by the racy description of the exhibits, associated with incidental reminiscences, told with all the charm of a *raconteur*.

Perhaps second to his life on shipboard, in importance and in the pleasure it gave him, was his strong advocacy for a powerful Navy. His public life, indeed, was closely identified with the Navy. His twenty years in the House of Commons, from 1865 to 1885, gave him many opportunities for studying naval and imperial problems, and for five years he served with distinction at the Admiralty, from 1880 to 1884 as a Civil Lord, and for a year further as Parliamentary Secretary. Later, in the House of Lords, he found equal scope for the advancement of the same interests. He was elected President of the Institution of Naval Architects in 1893, and the members regretted his resignation, two years later, but it was inevitable upon his appointment as Governor of Victoria, a distinguished position which he occupied until 1900. On his return to England he continued his active and keen interest in the Institution, and there have been few meetings at which he was not present, exercising a guiding and stimulating influence in the affairs of the Institution. After all, however, his greatest service to the Navy was in connection with the world-known "Naval Annual." In 1881 he had

published a work of five volumes on the British Navy, showing great erudition and painstaking care to present the naval problem in all its bearings. One of these volumes was concerned with *materiel*. The public recognition of the utility of the presentation of contemporaneous history of the navies of all nations was so pronounced that Lord Brassey was induced to found the now famous "Naval Annual." The first volume was published in 1886. The "Annual" from the first was recognised as the most authoritative compilation on the composition of the fleets of every nation, and Lord Brassey's tables of comparative strength were accorded almost official recognition. His review each year of naval questions, and the ever-varying elements in the design of that composite structure the battleship, were given a reception which, while flattering to a civilian, was fully justified by the technical knowledge disclosed. Although the editorial work later passed to his son, Mr. T. A. Brassey, his lordship, right up to the last issue, was a guiding spirit and almost a yearly contributor, so that the successful development of the "Annual" and its present high eminence are in a large measure due to him. His sound judgment, wide knowledge, and fair and wise discrimination made him invaluable as the chairman or member of public inquiries, and amongst the Royal Commissions on which he served were those associated with unseaworthy ships, defence of coaling stations, relief of the aged poor, the opium traffic, and canals and inland navigation.

Lord Brassey was made a K.C.B. in 1881, when he was at the Admiralty, and was created a baron in 1886. In 1906 he was promoted to the Grand Cross of the Bath, and in 1911 was made an Earl. From 1908 to 1913 he was Lord Warden of the Cinque Ports. He had received many academic and other distinctions. Oxford University, of which he had been in youth a distinguished student, taking honours in the School of Law and Modern History, very appropriately made him a D.C.L., while Dublin conferred upon him the honorary degree of LL.D. He was made a Commander of the Legion of Honour in 1889, and received the Grand Cross of the Order of the Crown of Italy. But probably his greatest reward was the strengthening of the British Navy and the growth of the human bond which to-day binds the Empire together. It is appropriate that his son, Viscount Hythe, who succeeds to the title, has in both respects shown himself a keen and well-informed enthusiast, so that the traditions of the Brassey family will be maintained and strengthened.

PROBLEMS IN ATOMIC STRUCTURE.

On Saturday afternoon last Sir J. J. Thomson, O.M., P.R.S., delivered the second lecture of his course on the above subject.

On the last occasion he had, he said, described how an estimate as to the number of electrons in an atom could be arrived at by a study of the scattering produced by them when exposed to Röntgen radiation. Provided that certain conditions were satisfied the energy in this scattered radiation was proportional to the number of electrons in the atom. He proposed that afternoon to explain more fully what these conditions were that must be fulfilled if this proportionality between the two was to hold. As he had pointed out in his previous lecture, it was not always the case that the number of the electrons in the atom was proportional to the energy in the scattered radiation, and this being so it was very necessary to see what the essential conditions were. He thought that the nature of these would come out clearly if we considered what would happen in the case of two electrons only.

Suppose two electrons A and B (Fig. 1) were exposed to Röntgen radiation coming from a distant source, O, and let the energy of the radiation scattered by them be observed at P, also at a great distance from the particles as compared with the distance A B. The energy in the scattered radiation received at P depended upon the difference in the length of the paths O B + B P and O A + A P. If from B we drew B o perpendicular to O A and A p perpendicular to B P, then, remembering that O and P were both at a very great distance from the electrons as compared with the distance A B, the two lines O A and O B might be treated as if they were parallel, as also the two lines A P and B P. Hence the difference in the total lengths of the two paths was simply A o — B p.

The difference in the phases of the pulses arriving at P from A and B respectively depended upon this difference in the path lengths. This difference had a maximum value when the scattered ray was sent back in the direction of the origin, and if the distance A B was small in comparison with the wave length, both pulses would reach P in phase, and the energy of this scattered radiation would then be proportional to the square of the number of the electrons concerned. Hence the one condition essential to success in using the scattering of

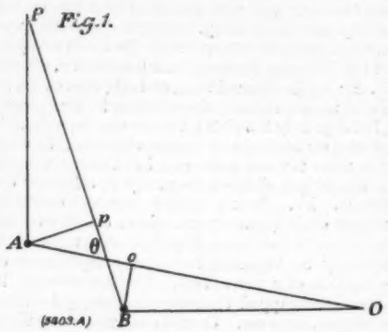


Fig. 1.

Röntgen rays for estimating the number of electrons in the atom was that the distance between the electrons must not be small compared with the wave length.

In the other extreme, when the distance A B was very large, a very small change in the angle which A B made with the incident radiation, might make a difference of several wave lengths in the paths of the two pulses arriving at P, and the relative phases of the two on reaching this point would be quite arbitrary. In that case the amplitude of the disturbance at P would be proportional to the square root of the number of the electrons, whilst the energy (which varied with the square of the amplitude) would be directly proportional to the number of the electrons concerned. Hence, when A B was very large compared with the wave length of the incident radiation, the necessary conditions for a reliable estimate were satisfied.

We had thus, the lecturer continued, the solution for the two extreme cases, viz., when A B was relatively very small and when it was relatively very large. It was of interest to work out the solution for the intermediate case in which the wave length was comparable with the distance between the two electrons. In practice, of course, we had unavoidably to deal not with just two electrons, but with a number arranged in all sorts of ways, and we could accordingly only deduce the average result to be expected when the lines drawn between all possible pairs of the electrons were assumed to come out in all possible directions. As a first step to fixing this average value we might, however, consider the case of two electrons only, and determine the average result when the line connecting them made every possible angle with the direction of the incident ray. It then appeared that the energy of the light scattered to P depended upon the angle θ which the scattered ray made with the incident ray. If, in short, δ were defined by the relation

$$\delta = 2\,A\,B \sin\frac{\theta}{2},$$

then the energy scattered to P was proportional to the expression

$$2 + 2\left(\frac{\sin\frac{2\pi\delta}{\lambda}}{\frac{2\pi\delta}{\lambda}}\right).$$

This was a function which began by attaining its zenith at the very moment of its birth, being a maximum when δ was zero. As δ increased, the function did not for some time alter appreciably in value, but then senile decay rapidly set in, and it fell off abruptly and reached a minimum value, afterwards rising again to a new but lower maximum. The characteristics of the function were shown in Fig. 2, where it would be seen that the amplitudes of the variations got smaller and smaller as δ increased and they finally faded away into insignificance. It would be seen that the above expression, for the energy scattered, comprised a steady effect with a fluctuating term superimposed on it.

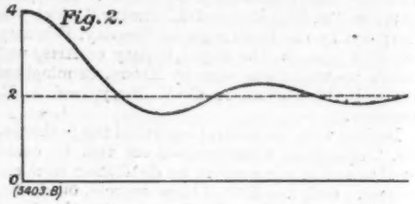


Fig. 2.

The value of δ depended upon the angle θ between the direction of the scattered light and the incident light, and if this angle were altered there should be variations in the brightness at P as the position of P was changed relatively to the incident ray (Fig. 1). Hence if the radiation were received on a screen, we should expect that there would be a series of rings alternately dark and bright surrounding a centre. This effect could, the speaker stated, be readily shown with ordinary light. Throwing a spot of bright light on to a screen and interposing in the path of the beam a plate of glass covered with lycopodium, the lecturer showed that the spot of light on the screen was then surrounded by a series of coloured rings, which were due to the light scattered by the lycopodium powder and corresponded to the maxima and minima of the function given above. The diameters of the rings were, the lecturer pointed out, much smaller than of those observed in a further experiment in which the lycopodium powder was replaced by a layer of crystals of alum deposited on a glass plate. In this latter case the formation of the rings was due, the lecturer said, to refraction from the crystal faces, and was not due to scattering at all.

When, in place of two particles only, we had to deal with a number N, say, the expression for the energy comprised a number of terms of the form,

$$2\left(\frac{\sin\frac{2\pi\delta}{\lambda}}{\frac{2\pi\delta}{\lambda}}\right),$$

where δ represented in succession the distance between any one of the N particles and every one of the others. As before the effect changed with the angle θ, and was greatest when θ was zero; that was to say, when the direction of the incident ray and that of the scattered ray coincided, P (Fig. 1) being then on the left hand side of A B directly opposite to O.

The distribution of the energy in the scattered radiation was thus not symmetrical fore and aft unless A B was very large compared with the wave length. Practically there was always a large excess radiation scattered behind the object as compared with the amount scattered in front of it. Analysis showed, in short, that owing to the effects of interference the maximum effect was obtained in the line of propagation of the incident ray. Here, also, was to be found the explanation of the fact that we did not see this scattering when light passed through solids which contained, of course, an enormous number of particles. Why, in such cases, did the light appear to go on in its original direction and not flare out at right angles to this path? The reason was that the light scattered by the particles in the direction of the propagation came out in phase, whilst in that which was sent off at right angles to this there were great variations of phase. In the first case, therefore, the energy in the scattered radiation was proportional to N^2, whilst the light scattered transversely had an energy proportional only to N. Since in solids there were hundreds of particles in a wave length, the difference between N^2 and N was enormous, and the energy in the light scattered in the direction of the propagation was out of all proportion greater than that of the light scattered in the transverse direction.

There was, the lecturer proceeded, another case in which the pulses from particles would be in phase. Thus, in Fig. 3, if P were placed so that P C and C O made equal angles with A B (C being the mid-point of A B) the two pulses from A and B would reach P in phase. In that case the direction between the incident and scattered ray was the same as if A B were a mirror and C P the reflected ray. Hence, if there was a large number of particles in one plane, then no matter what the wave length of the incident light might be, the light scattered by the particles to a point P would have a maximum intensity when P lay in the direction in which light from O would be reflected when a mirror was substituted for the layer of scattering particles.

In all the experiments of which particulars had so far been published it had been assumed that the energy of the scattered radiation was directly pro-

Fig. 3.

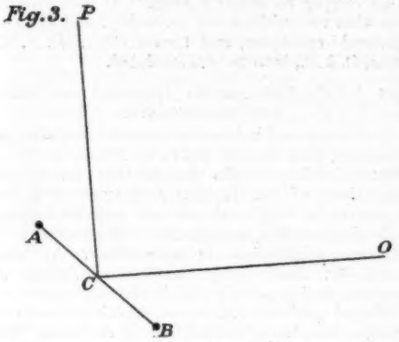


Fig. 4.

portional to the number of electrons in the atom. The speaker was, he said, not sure that sufficient attention had been paid to the necessity of keeping the distance between the particles large in comparison with the wave lengths used, and a correction of several per cent. might, he thought, be necessary. Taking the experiments as they stood, however, the observations of Barkla and Crowther showed that the number of electrons in a molecule of air was somewhere about 14, which indicated that the atom of nitrogen had 7. Other gases had also been studied, and the results indicated that the number of electrons was roughly proportional to the atomic weight, and within an error of a few per cent. could be represented by one-half the atomic weight when this was an even number, and by $\frac{A-1}{2}$ when the atomic weight A was odd.

The speaker's own impression was, however, that the reliability of the interpretation of these experiments had been exaggerated, and it was desirable that the experiments should be repeated, taking into account the considerations he had advanced above. He would, moreover, emphasise the fact that the possibilities of experiments on scattering had not yet been utilised to the extent of which they were capable. Experiments of this kind ought to give us, not merely data as to the number of electrons in the atom, but also some information as to their arrangement. To illustrate what he had in view, he would suppose that an atom contained four electrons and that it was desired to know how they were arranged. They might, for example, be situated at the corners of a square, or at the corners of a tetrahedron. Both arrangements were symmetrical and in both cases the electrons would be positions of equilibrium, though whether this equilibrium was stable in both cases was another matter. Neglecting this latter consideration, however, the character of the scattering effect would be different in the two cases. In the tetrahedral arrangement the length of any possible line drawn between any pair of the electrons was the same, and the expression for the energy would contain but one value of δ. If, on the other hand, the electrons were arranged at the corners of a square, the diagonals of the square were longer than the sides, and the expression for the energy of the scattered radiation would contain accordingly an additional sine term. It would seem, therefore, that if we could carry further our experiments on scattering, additional light should be thrown on the structure of the atom.

Assuming for the present, however, that the number of electrons present was equal to half the atomic weight, what was their configuration inside the atom? As to this there were two extreme views. Atoms were electrically neutral bodies. If they contained electrons, there must be something else there which carried, to use ordinary language, a positive charge of electricity, just sufficient to balance the negative charges of the electrons. The question that arose was to how this positive charge was distributed. Two extreme cases might be taken. In the first place the positive charge might be considered as concentrated in an excessively small space, just as that of the electron was. This concentrated charge occupied the centre of the atom, and the electrons were arranged around it and repelled each other whilst being attracted by the central positive charge. The other extreme view was that the positive charge was distributed uniformly throughout a sphere of large size as compared with the electron. In this case the attractive force on an electron was proportional to its distance from the centre.

The difference in the conditions necessary in the two cases for static equilibrium was great.

In both cases if an electron was to be equilibrium it must occupy some position in which its attraction for the positive charge was just balanced by the repulsive force exerted by the other electrons. When the positive electricity was distributed uniformly throughout a large sphere this equilibrium was stable; and any electron returned to its former position if displaced. Here stable equilibrium was secured simply by the mutual attractions and repulsions of the charges concerned.

In the other extreme case in which the positive electricity was assumed to be concentrated at the centre of the atom, calculation showed that positions could also be found in which the electrons were in equilibrium under the attractive and repulsive forces concerned, but it turned out that this equilibrium was unstable.

To illustrate this the lecturer floated on water a magnet representing the positive charge. This was placed with its axis vertical. Another magnet, with poles reversed, to represent a negative charge, was attached to the first, but kept from coming into actual contact with it by a distance-piece represented by the bar in Fig. 4, where a represents the positive charge and b the attached electron. It was then shown that there was a point somewhere along the line R T in which a second "electron" c was in equilibrium, but that if c were moved from this position it did not come back to it but travelled either out towards R or in towards the central charge.

In short, Sir Joseph proceeded, it was not possible to find a position of stable equilibrium for c when the forces of repulsion and of attraction on it both varied inversely as the square of the distance. Nevertheless, we knew that there were most important systems in the universe which were stable for all practical purposes under the action of forces of this kind. An example was provided by the planetary system. However, Mahommet's coffin would be unstable, being in a position exactly analogous to the equilibrium position for c in Fig. 4. Under such a system of attractions it was impossible to secure a condition of stable equilibrium unless the particle were in motion like the earth round the sun, where the attraction was balanced by centrifugal forces. He had calculated out the conditions of stable equilibrium for the electrons on an hypothesis which included that of stability due to rotation, viz., that the force on the electron was represented by the expression:

$$\frac{e\,e^1}{r^2} - \frac{e}{r^3} \quad . \quad . \quad . \quad . \quad (1)$$

where r denoted the distance between the mutually attracting masses e and e^1.

Another problem which arose was what amount of positive electricity would it be necessary to concentrate at the middle of an atom to keep the electrons in stable equilibrium under forces represented by equation (1).

If there were a great number of electrons, there would be no stability unless the positive charge was enormous, as was indicated by the following table:—

No. of Electrons	1	2	3	4	5
E/e..	0.70	¼	1.587	3.10	4.76
No. of Electrons	6	8	10	12	14
E/e..	7.32	14.20	24.16	38.95	58.44
No. of Electrons	16	18	20		
E/e..	83.6	115.4	154.5		

When the number was less than 5, it would be seen that there was an excess of negative electricity, whilst somewhere between 5 and 6 the two charges would be equal. The table, it should be observed, had been calculated on the assumption that the electrons were arranged in a flat ring round the positive charge. This was not the most favourable condition when the number of electrons was large, but the mathematical difficulties were increased very greatly if another dimension in space had to be taken into account. He had, nevertheless, been able to calculate out some figures of equilibrium for three dimensions. The tetrahedron was very stable, and the electrons arranged at the corners of an octahedron would be stable when the charge at the centre was not greater than the sum of the charges around it. The cube was not a stable form, but became so if one face was twisted round (in its own plane) through an angle of 45 deg. The icosahedron appeared to be just about stable, but the dodecahedron with 20 electrons, one at each corner, was certainly unstable.

Referring to the table above given, which applied to the case in which the electrons all lay in a flat ring, it would be seen that with a positive charge of 150 only 20 electrons could be held in stable equilibrium round it. There was thus an excess of 130 charges left. For points situated far away from the group, the total effect of the latter would be represented by a positive charge equal to this residue, and this might support another ring of electrons under forces varying according to the general law represented by equation (1). There would still be a residue left which could support a still more distant ring. Each successive ring would consist of fewer and fewer electrons.

This was the exact converse of what was found to be the condition for equilibrium on the alternative view, in which the positive electricity was assumed to be uniformly distributed throughout a relatively large sphere; the number of electrons near the centre was then small, the greater number being in the outer rings.

Some crucial points in such investigations as these depended on the atomic volume. This was defined as the $\frac{\text{density}}{\text{atomic weight}}$ and was not quite definite unless it were assumed that the atoms were hard incompressible spheres. To illustrate the difficulty in the above definition the speaker referred to the work of Osborne Reynolds, who was the first to account for the curious fact which must have been observed by everyone who walked on wet sand, viz., that the effect of the pressure of the foot was apparently not to drive out water into the sand round the footmark, but to dry it. In short, with well-settled sand, any disturbance increased the proportion of the voids to the total volume occupied. This property had been called that of dilatency by Osborne Reynolds, and he had elaborated it into what was almost a theory of the universe.

BRITISH OVERSEA TRADE MISSIONARIES.

THE paper read before the Royal Society of Arts on Wednesday last, on "The Organisation of Commercial Intelligence," by Sir William H. Clark, K.C.S.I., Controller-General of the Department of Overseas Trade (Development and Intelligence), did not give much information in addition to that already published in ENGINEERING in reviews of the extended utility of this Department, organised under the joint auspices of the Foreign Office and the Board of Trade. There was, however, afforded

a clearer indication of the functions of our British trade ambassadors, who will be known as imperial trade commissioners in the Dominions and of our "commercial attachés" in foreign countries. The number of the former, as already indicated, has been increased from four to sixteen, and we now learn that four will be stationed in important centres in Canada, two in Australia, one in New Zealand, two in South Africa, one in the West Indies, one in the Straits Settlement, and others will be for special service. The functions are: to keep in close touch with the Government and State authorities in the Dominions; to visit the principal commercial centres; to watch and report upon foreign competition and financial and trade conditions and new legislation affecting trade; to make an annual general report on the conditions and prospects of trade in their areas; and to furnish special reports and monographs on particular questions which are likely to be of interest to British trade. Moreover, the commissioners in any particular area are also to be at the disposal of any of the Dominions or of India which may not have representatives of their own in the area concerned, so that it will be part of their duty to promote inter-imperial trade as well as the trade of the United Kingdom.

As regards the commercial attachés their services are to be developed on a thoroughly comprehensive scale, and their number, which prior to the war was eight, will be very considerably increased. It will be part of the duty of each attaché to superintend the commercial work of the consular officers in his area and to call upon them for information, so that much of their work will tend to be focused through him and be influenced by him. He will have to deal with the larger inquiries affecting the trade of the country as a whole, to furnish an annual report and monographs on special topics, to keep in close touch with the British Chambers of Commerce of foreign countries and with the British commercial community, generally assisting them in every possible way. British business men who visit foreign countries are expected to call upon the commercial attaché, and thereby maintain close relationship with him. Much of the success of the department depends on the suitability and energy of commissioners and attachés, and Sir Arthur Maitland, chief of the department, stated in the House of Commons, on Tuesday, that the first attaché appointed was not only completely bilingual with regard to English and the language of the country to which he was going, but he had taken a degree in engineering both in this country and in the country to which he was going. If this is a criterion of the standard to be achieved there need be little apprehension on this score.

The attachés, as well as the Dominion Trade Commissioners, will pay periodic visits to this country, visiting the manufacturing areas, conversing with the tradespeople generally, and acquiring a definite intimacy with the scope, processes and manufactures of our great industrial concerns. We are glad to note, too, that there is to be a greater extension of the practice of having special expert investigations of markets abroad, to be conducted by commissioners appointed because of their special knowledge of the productions of this country, if not also of the requirements of the Dominions and of the foreign countries. This will apply specially to possible openings for any particular industry. Already one such inquiry has been instituted in the Argentine, and the procedure is indicative of that which will, no doubt, be followed in subsequent cases. The expert, in this instance, spent some months in studying the products and methods of manufacture of the firms concerned before starting on his tour. He carried samples to the Argentine, collected samples of competitive goods there, and, although he did not take orders, he succeeded in awakening interest in British manufactures, and facilitated the ready adaptation of the products of the British firms to meet the fuller requirements of the different markets. In this work such organisations as the Federation of British Employers, the Chamber of Commerce, and the British Empire Producers' Association can be of invaluable help to the Department. But it is very necessary that, in order to give such expert missionaries of industry a broad foundation on which to work, there should be a greater merging of such organisations as we have mentioned, and a less multiplication or diffusion of effort.

Perhaps the outstanding contention of Sir William Clark's address was the recognition of the importance of collaboration between the Department and manufacturers and such organisations as mentioned. They can help much, not only in directing the work of the commissioners in the Dominions and in the foreign countries, but in the institution of such special inquiries abroad. As it is, nearly 10,000 separate traders are in association with the Department supplying particulars on special forms, comprising the main preliminary particulars which it is necessary for a firm in this country to know when they contemplate opening up business with an importer's house abroad, European references, the general nature of the business and the terms on which they treat. Between 3,000 and 4,000 firms, too, are on the register, to whom intelligence is supplied on foreign competition, reports on various industries in countries overseas, and on general and commercial conditions. Reports on particular trades or markets are also despatched to these. Sir William Clark appealed for an increased number of firms to secure the benefit of the investigations made by the Department. As he remarked in concluding, a Government Department cannot help the commercial community efficiently unless it works in the closest co-operation with it, and unless manufacturers and traders are determined to assist and utilise such Department to the fullest advantage.

NOTES.

THE INSTITUTION OF NAVAL ARCHITECTS.

IT is gratifying to find that the forthcoming annual meeting of the Institution of Naval Architects, notwithstanding war exigencies, promises to be more interesting than on some former occasions. It is inevitable that naval questions should be avoided, but the merchant shipbuilding papers are of a broad character and promise discussions of a suggestive nature. After the Earl of Durham has delivered his presidential address on Wednesday, the 20th inst., a paper will be read on "Standard Cargo Ships," by Sir George Carter, K.B.E., who, it will be remembered, was chairman of the Shipbuilding Advisory Committee acting under the Shipping Controller, and was therefore closely identified with the design of the first of these cargo ships. The second paper will be by Mr. John Anderson, and is entitled "The Most Suitable Sizes and Speeds for General Cargo Steamers," a subject of very wide importance. On Thursday, the 21st inst., the proceedings will open with two papers of national importance. One, by Mr. W. S. Abell, the chief ship surveyor at Lloyd's, is on the "Problems of the Future in the Design and Construction of Merchant Ships," and the second, by Mr. A. E. Seaton, is "On the Value of Research Work in Marine Engineering." Both subjects are not only attractive but of great importance from the point of view of our future maritime prosperity. It is hoped that the views of shipowners will be freely expressed for the benefit of naval architects, because, after all, the latter are more or less the servants of the former, and consequently guidance must be of incalculable benefit to them. The third paper on Thursday is by Mr. G. S. Baker, O.B.E., of the Experimental Tank at the National Physical Laboratory, and Miss E. M. Keary, one of the staff. In this connection it is noteworthy that this is the first occasion on which a lady has been co-author of a paper at the Institution. The subject is "The Effect of the Longitudinal Motion of a Ship on its Statical Transverse Stability." At the afternoon meeting on the 21st inst., the two papers deal with problems in metals. The first is on "The Iron Carbide Equilibrium Diagram and its Practical Usefulness," and is by Professor H. C. H. Carpenter, while the second, on "Stress Distribution in Bolts and Nuts," is by Mr. C. E. Stromeyer. Friday's proceedings will be largely taken up with the subject of ferro-concrete ships. Three papers are down for discussion, and it is hoped that the consideration of these will lead to the crystallising of opinion on the divergent views regarding the future permanence of this war development in shipbuilding. Major Maurice Denny, who is a leading member of the staff of the Controller of Auxiliary Shipping at the Admiralty, and the son of Sir Archibald Denny, reads a paper on "A Preliminary Survey of the Possibilities of Reinforced Concrete as a Material for Ship Construction." Mr. Walter Pollock gives his paper the simple title of "Reinforced Concrete Ships," while Mr. T. G. Owens is more definite, dealing with the "Design and Construction of the First Self-Propelled reinforced Concrete Sea-Going Cargo Steamer Building in Great Britain." The other paper on Friday morning is entitled "An Investigation of the Shearing Force and Bending Moment acting on the Structure of a Ship, including Dynamic Effects," by Mr. A. M. Robb, B.Sc., while the afternoon of the 22nd is to be devoted to a paper, by Mr. R. W. Allen, C.B.E., on a subject on which he has made very extensive experimental tests, namely, the "Air Supply to Boiler Rooms." It will thus be seen that the subjects are diversified, and of great practical importance, and the secretary, Mr. R. W. Dana, O.B.E., is to be congratulated.

THE L.C.C. REGULATIONS RELATING TO REINFORCED CONCRETE.

In a paper read before the Concrete Institute, on Thursday, February 28, Mr. C. F. Marsh, M.I.C.E., drew attention to the danger that the official regulations of the London County Council for structures in reinforced concrete may be adopted by local authorities throughout the kingdom without further consideration or amendment. As they stand, Mr. Marsh holds that the regulations in question tend to restrict unduly the employment of reinforced concrete. Moreover, certain clauses are, he says, less clearly worded than is desirable. Mr. Marsh specially criticised the rules for estimating the strength of different concrete mixtures which, he contended, gave too low results for mixtures richer than 1 : 2 : 4. For the strength of concrete at one month the author proposed the formula

$$u_1 = 5{,}400\, r_c,$$

where u_1 denotes the crushing strength in pounds per square inch and r_c the ratio of the volume of the cement used to the volume of the cement plus the sand. The author suggests that the working stress should be taken as one-third of the above value. The following table permits of a comparison between the author's proposed rule and those in use elsewhere.

Volumetric Proportions.	1 : 1.75 : 3.5		1 : 1.56 : 3.12		1 : 1.37 : 2.75	
	Compressive Strength at 28 Days.	Compressive Working Stress.	Compressive Strength at 28 Days.	Compressive Working Stress.	Compressive Strength at 28 Days.	Compressive Working Stress.
	lb. per sq in.		lb. per sq. in.		lb. per sq. in.	
French Commission ..	1,520	638	1,706	717	1,890	798
L.C.C. equations	1,750	638	1,864	666	1,976	694
Author's equation ..	1,963	654	2,106	702	2,279	760
American Committee's equation..	2,250	731	2,440	793	2,682	854

Mr. Marsh further suggests that the adhesion between the concrete and the reinforcement may be taken at 100 lb. per square inch in all cases. Mr. Marsh takes the view that the 16,000 lb. per square inch working stress on mild steel allowed by the London County Council Regulations should be reduced to 12,000 when the steel is used in "diagonal tension." With high-tensile steel he suggests that a working stress of 20,000 lb. may be permitted. The width of flange allowed by the regulations in calculating T-beams is, Mr. Marsh states, considerably less than has hitherto been admitted to be perfectly safe, and he finds no justification for the reduction. Speaking generally, he contends that the London County Council regulations are unnecessarily restrictive also with respect to the design of pillars and struts, and he believes that if they are insisted on, the use of either ordinarily reinforced or hooped compression members will be economically possible only in rare instances. In particular the regulations provide that the effective diameter or that to the outside of the outermost longitudinal reinforcement shall be used in all calculations for

compression members, whether reinforced in the ordinary way or hooped. This provision, Mr. Marsh says, is unnecessarily restrictive on the employment of columns reinforced in the ordinary way, and he strongly urges that the resistance of reinforced concrete compression members of this character should be permitted to be calculated on the outside sectional area with working stresses on the concrete five-sixths of those given by his equation. A similar method of calculation for ordinarily reinforced compression members has, he says, been the universal practice up to the present and has proved perfectly safe and reliable, and there appears no justifiable reason for the restrictions imposed by the London County Council regulations.

Progress in Shipbuilding.

When it is possible to write with fulness of our industrial activities during these strenuous times it will be seen that "shipbuilding has moved as far and as fast on unconventional lines as during any previous year." This statement was made by Mr. Fred. J. Stephen, the chairman of the Technical Committee, at the annual meeting of the British Corporation for the Survey and Registry of Shipping. The work done, however, as he pointed out, was mostly of a confidential character, but it had been stimulating and full of promise for the future of shipbuilding. We have already reviewed in ENGINEERING the new rules brought into force during the year, and Mr. Stephen was able to draw from experience so far gained the view that the new rules have realised the highest expectations, and any doubts which the Technical Committee might have had as to public objection to more elaborate methods of obtaining accuracy had proved unimportant; public opinion realised that accuracy was simpler in the end. Like the chairman of the corporation, Mr. Robert Clark, he emphasised the importance of minimising weight in the scantlings. Mr. Clark enforced the view that a reduction in the weight of material which enters into a structure does not necessarily mean loss of strength; on the contrary, additional weight may even be a source of weakness. Strength depends much more on the proper apportionment of the material than on its weight, and the most successful design was that which produced the strength required by the skilful distribution of the smallest possible weight of materials. As Mr. Stephen pointed out, the practice of the corporation had been to maintain and even increase their standard of strength, which was already the highest, in order to weed out wasteful and insufficient material and to encourage improvements in structural design with these objects in view. The corporation, it is interesting to note, for the past year prepared rules for the construction and maintenance of wooden ships, in order to provide tonnage without the use of steel, which is in such great demand. In this work, as in the preparation of the main rules, there was obtainable the co-operation and experience of the Registro Navale Italiano and the American Bureau, both of whom had considerable experience in timber shipbuilding. As regards the ferro-concrete ship, the view is taken that there will be considerable developments in this form of structure, especially for small craft. Mr. Stephen remarked that the science of ferro-concrete construction as applied to shipbuilding has advanced more in months than it would have done in years under normal life. Many designs have been considered by the committee after careful analysis in the light of all available experience. Some had been rejected and others had been chosen for acceptance as sound experimental propositions. It remained, however, to be proved from experience whether the advantages outweighed the disadvantages of this material, and, further, when the material had been proved suitable for the work to be done, whether cheapness, rapidity of construction and saving of upkeep would make these ships strong competitors of the lighter and more costly steel ship. If the serious development of the "cast" ship should lead to the discovery of a composition more elastic than concrete, in the sense of stretching and closing without cracking, to a degree which would harmonise with the movement of steel under stress, there could be no doubt as to the great possibilities of this form of shipbuilding, because the economy in it was practically that which casting had over forging. Mr. Stephen also drew attention to the work being done by the committee to arrive at suitable commercial standards for electrical work on board ship.

PROPOSED NEWCASTLE SECTION OF THE JUNIOR INSTITUTION OF ENGINEERS.

To the Editor of Engineering.

SIR,—The note in your issue of February 22, regarding the proposed formation of a Newcastle section of the Junior Institution of Engineers, is not calculated to leave a very happy or, I consider, true impression on the minds of interested members of the profession, or of prospective members of the Institution as to the position and future of the proposed section.

At the meeting held in Newcastle on February 12, which I attended simply as a person interested in the movement, the seconder (Mr. J. R. Beard) of the suggested amendment definitely stated at the close of the meeting that, since the meeting had definitely settled to form a local section of the Junior Institution of Engineers, no opposition of any description was to be anticipated from his Institution (the I.E.E.) and, on the contrary, he assured the chairman of the meeting that the I.E.E. would do all in their power to promote amicable relationships between the Newcastle section of the two Institutions.

Both proposer and seconder of the suggested amendment are accredited and responsible members of the Newcastle section of the I.E.E., and the definite statement made by the latter is quite sufficient to scotch the "conflict" bogey.

I, personally, also regret that Mr. Tookey did not accept the proposed amendment, but for a very different reason to that given by you. Had he done so, the disapproval of the amendment by practically the entire meeting would have immediately become apparent, as, indeed, it was so, on a show of hands later in the evening.

Coupled with Mr. Tookey's assertion that there was no desire to be competitive, and with Mr. Beard's statement above referred to, the remarks in your notes are particularly to be regretted, and it is certainly to be hoped for that the council of the Institution in London do *not* enter into negotiations with existing institutions in Newcastle before agreeing to what has been shown to be a very necessary requirement, the formation of a Newcastle section of the Junior Institution of Engineers.

Yours faithfully,

S. AUSTEN STINGAT,

18, The Grove, Benton, Newcastle-upon-Tyne.
February 26, 1918.

[The Newcastle Section of the I.E.E. is not the only possible source of conflict.—ED. E.]

SHIPBUILDING EFFICIENCY.

To the Editor of Engineering.

SIR,—Three and a-half years ago Admiralty began to take over from the merchant service large numbers of ships whose constructional details had been justified by the eliminatory process of long and arduous service. This proof notwithstanding, an immense amount of money was thrown away and invaluable time lost, while proved methods and material were scrapped and brought up to the then accepted Admiralty standard.

Marine engineers and naval architects looked on in pitying wonder, made good-humoured allowance for the official mind, and accepted the inevitable with mild and persuasive protests. This wise procedure bore good fruit, and with the entry of a large leaven of mercantile men into the Admiralty service it did at one time appear to have brought about a reasonable modification of the bureaucratic mind.

But as time has gone on there has accumulated evidence in many directions that the old and pernicious pedantic methods are once more submerging the enlightened experience which Admiralty administration had learned at such tremendous cost of time and money. An extraordinary and regrettable circumstance is that this system of administration appears to have already imposed its paralysing effects upon the large civilian element which was introduced into it with such good effect in the first instance.

One perceives unmistakably in many departments of Admiralty that loss of initiative and decision, and that reluctance to assume responsibility which is so characteristic of those below the highest officials of all British bureaucracies.

Precisely the same thing is developing in some of the most recent expansions of War Office administration where at the outset efficiency and rapidity of decision and execution were of the highest order, and far ahead of anything approached by the Admiralty administration. The root causes, in the opinion of one who has had a good many years experience of British bureaucratic administration are, in the first place, over-centralisation, coupled with the committee system, and, in the second, the heresy that all progress must emanate from the top downward.

The effect is slowly but surely to envelop even the most efficient man, if endowed with powers of initiative and decision, in a whirlpool of official correspondence and procedure. With the result that he eventually spends his time at a desk pushing papers about, and is compelled to restrict his work to what can be accomplished by subordinates. Their action he has in turn to control by a further extension of the paralysing system because he cannot devote his personal attention to the things that really matter.

The waste of money, and, still more important, the waste of intellectual energy of the highest attainment, engendered by this national and characteristic weakness of administration is appalling to those who have opportunities of observing their effect. The most effective check and eventual remedy for what is undoubtedly a national disease is frequently to change the highest officials of departments. This drastic procedure would have the effect of compelling a healthy degree of decentralisation and would throw responsibility upon the lower orders and necessitate the display of their abilities. No efficient subordinate would have cause for fear or complaint and the sense of unavoidable responsibility which cannot be passed on step by step to the next in command would encourage and develop efficiency right down.

The pressure of public opinion will alone bring about and maintain a proper state of efficiency in public administrations. The expression of such opinion, unpolitical and unbiassed, can only be exercised through the medium of such a journal as ENGINEERING. If, therefore, you can find space to formulate and encourage its development and expression you will, Sir, in my opinion, earn the thanks of the nation at large.

I am, Sir, yours faithfully,

"A BUREAUCRAT."

February 20, 1918.

THE MEASUREMENT OF CURRENT IN ELECTRICAL IGNITION SPARK CIRCUITS.

To the Editor of Engineering.

SIR,—Mr. Morgan, in his reply to my criticism of his article, has not removed the obscurities to which I drew attention, nor met my objections to several of his statements therein, except by making fresh assertions, one of which at least is also incorrect. He states that "if a magneto is running at constant speed, the energy content of the sparks is practically constant over a wide range of spark-gap variation. Variation of voltage *must*, therefore, be accompanied by an opposite variation of current." (The italics are mine.)

My experiments show that this is not so, and that increase of voltage and increase of current may go together in certain conditions, while the reverse is the case in other circumstances. The reason for this is clearly due to the highly complicated nature of the secondary discharge, so that the phase relationship between the current and electorate force is not constant. His assertions and the opposing experimental facts support my original main contention, viz., that the secondary current is too complex, for one to have any *a priori* ideas about it.

Yours truly,

G. E. BAIRSTO, D.Sc.

Royal Aircraft Factory, South Farnborough,
February 26, 1918.

CONCRETE SLEEPERS.

To the Editor of Engineering.

SIR,—We were very much interested in your article publishing results of investigations by Messrs. Green and R. St. George Moore, on a form of concrete sleeper with a resilient chair. The importance of work in this direction may be gathered from the fact that a reliable railway authority estimates that some 50,000,000 acres of forest land are required in the States to provide the timber annually required for sleepers, including renewal of old sleepers and provision of sleepers for new lines. Probably one-twentieth part of this area is required for English railways; it is difficult to see that this acreage of forest can be spared for the purpose nowadays.

Steel, cast-iron, and concrete have been tried as substitutes, and most of the pioneer work among these materials appears to have been done in India, where the white ant is such an enemy to wood. Germany, however, as might have been expected, has contributed her share and has established an automatic circular-testing track, where electric unmanned trains career round all day long, testing a railway track under definite conditions.

All early attempts at making concrete sleepers took the form of a wooden sleeper cast in concrete; this is, of course, hopeless; a new material demands absolutely appropriate lines; and as wood is so essentially different from concrete, it is quite clear that a concrete sleeper must not merely imitate a wooden sleeper. The sleeper illustrated on page 191 of your last issue very obviously conforms to this criticism, but it is apparently influenced by the idea of the well-known D.O. sleeper, having some of the good points and some of the bad points of this sleeper, with probably additional good and bad points of its own; it would appear to us (but not being railway engineers the opinion carries little weight) that a weak point of the D.O. sleeper is that the gauge cannot be adjusted, while the gauge of the Indian pot sleeper can. The D.O. sleeper would, however, appear to have the advantage that it can be readily packed, whereas the pot sleeper has to be packed partly through the holes left in it. The pot sleeper would appear better able to resist creeping and lateral displacements, although the fin on the D.O. sleeper is probably effective, to a certain extent, against the latter.

The method of suspension for the rail in the new concrete sleeper invites criticism, but as so many apparently impossible things become accepted practices in engineering, one naturally is rather cautious in forming a judgment. From our experience of reinforced concrete we would be inclined to think that the proposed steel chair is bound to be a failure. We do not think it can be regarded as good practice to allow any part of the reinforcement of concrete to pass out through the

exterior if it can possibly be avoided, as a passage is at once made for the entrance of moisture, with the result of rapid disintegration of the concrete through the action of frost; the present sleepers have been tried in India, possibly in districts unvisited by frosts, but we do not think they would last for two winters in England. The photograph also shows them as laid on the tangents; even here, however, there is considerable lateral thrust. Now, it seems to us, that if the keys in the tie-bars were overtightened, the steel plate would be bent in, resulting in eccentric loading, even with a vertical load, and this would be accentuated by driving in the wooden key. When you come to horizontal thrust, however, this liability of the steel chairs to bend and open would be much increased. Of course, a few yards of experimental sleepers can easily be laid down on a short stretch of railway, and give satisfactory results, because they are probably put down under special supervision; when, however, the sleepers are laid in the ordinary maintenance of the line, they would not receive this special attention, and all their weak points would develop.

To be a financial success concrete sleepers must obviously last from twenty to thirty years, and we are entirely hopeless of such a result being attained with concrete sleepers in which the reinforcement comes through the surface. We are ourselves carefully studying the problem although, possibly, we shall have no more success than anyone else.

We have, however, a supply of about 1,000 tons per day of the finest concrete aggregate, all or part of which is available for making sleepers; this would be sufficient for 6,000 sleepers per day. We have also some miles of railway track to experiment on. If our efforts can in any way help to relieve the wood supply problem, we shall feel we have at all events done our bit.

It seems to us that a concrete sleeper should fulfil the following conditions: It should be fairly light, and easily handled; its life should be about thirty years; it should not form a hard road; it should be easily packed, its gauge should be adjustable; it should offer due resistance to creeping and to lateral movement; it should not introduce radical departures into permanent-way construction and maintenance.

Perhaps we are unwise to trench on a province of railway engineering, but we are exceedingly interested in this problem, and are indebted to you for your article on the matter. Doubtless some of your readers can add to, or subtract from, the above desiderata, or supply any other points that may be useful to ourselves or others in this matter.

Yours faithfully,
TRENT CONCRETE, LIMITED,
E. F. S., Chief Engineer.

February 25, 1918.

CONCRETE COTTAGES.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been drawn to a letter over the signature "Philadelphian" in your issue of January 4, in which it is stated that, as a material for the construction of buildings intended for the dining and sleeping accommodation of operatives in large works "concrete has been tried and has proved a failure in several important particulars." "Concrete houses," your correspondent says, "are very cold, and condensation inside of moisture from the atmosphere is excessive and incurable. The great primary cost of such houses is only equalled by the heavy outlay for maintenance." These are statements which should not be allowed to pass unchallenged. If they are the outcome of experience, the experience must have been peculiarly unfortunate, and I feel convinced that, upon a close investigation it would be found that where such faults exist they are not due to any defects inherent in the concrete itself but are the result of bad workmanship, or failure to adapt the composition of the material to the purpose for which it is to be employed. Will you allow me, Sir, to consider the three points raised, viz.: (i) The coldness of concrete houses; (ii) the condensation of moisture inside; and (iii) the outlay for maintenance.

(i) Presumably, when it is stated that a house is cold, reference is made to the atmosphere within the building. It is an established fact that the power of concrete as a heat conductor is low, and, consequently the warmth within the house will be retained. It is, therefore, difficult to understand why a concrete house should be colder than a house built of any other material; and, further, if the cavity-wall system of building be adopted it may be stated with certainty that the house will not only be absolutely dry within, but will be warmer in winter and cooler in summer than a building constructed in the ordinary way. I could quote the experience of people who have lived for years in such houses, but am forbidden by consideration for your space.

(ii) Condensation of moisture from the atmosphere on the walls inside a building occurs when the interior surfaces are non-porous, as, for example, when they are of marble or granite or are coated with a hard, non-porous material. In the case of a concrete structure, this may be prevented by two principal methods. One is the rendering, on the interior surface, with a plaster having a porous nature, such as lime plaster. Any moisture that may condense from the atmosphere will then be absorbed by the plaster instead of settling on the surface. The other method is the employment of a porous aggregate when making the concrete. In the case of a cavity wall, for the outer portion a good mixture and a non-porous aggregate should be used in order to ensure impermeability; and for the inner wall, a concrete whose aggregate consists of a porous material such as coke-breeze or clinker. If the walls are built of concrete blocks or slabs, these may be made with a facing mixture of good material for the exterior surface, and backed with concrete having a porous aggregate. This method, which may also be applied to walls of monolithic concrete, presents no difficulty in actual practice and is frequently adopted by the makers of concrete blocks and slabs.

A large number of concrete block buildings have recently been erected at a military camp in this country, and in no case has there been any trouble with condensation on the walls. The universal testimony of the soldiers who occupy them is that these buildings are dry, warm and comfortable.

(iii) It would be interesting to learn the details of "the heavy outlay for maintenance" mentioned in your correspondent's letter. If there is one characteristic more than another for which concrete can justly claim a superiority over other building materials it is that when carefully made and properly handled its cost for upkeep is practically *nil*. Where this is not the case, the failure may, in nearly every case be traced to faulty design or bad workmanship. Experiments, scientifically conducted, have proved that concrete increases in strength over a long period of time; therefore, since it does not itself deteriorate, and as plaster adheres perfectly to it, and distemper or specially-prepared paint may be used upon it, it is difficult to see in what way the "heavy outlay for maintenance" is incurred.

The fact that concrete is now being widely employed for buildings of all kinds, both temporary and permanent, surely speaks for itself, since it is only fair to assume that before adopting a method of construction which concerns so many of our workers and fighters, careful inquiries will have been made as to its suitability for the purpose; and so far from being a failure in the particulars specified, concrete has been proved by experience to be an undoubted success.

I am, Sir, &c.,
T. J. CLARK, A.C.I.
The Concrete Utilities Bureau, 6, Lloyd's-avenue,
E.C. 3, February 22, 1918.

SKILLED MEN.

TO THE EDITOR OF ENGINEERING.

SIR,—I think that it would be a good thing to get some common agreement as to what is meant by skilled, semi-skilled, and unskilled men, and I therefore submit a description of them for the consideration of your readers. I do not suggest that it is a necessary and unalterable definition, but it may perhaps serve as a basis.

1. A skilled man is essentially a man who has served an apprenticeship (indentured or other) to the trade in which he is and has been continuously employed since completing such apprenticeship. He is capable of exercising his skill independent of his surroundings.

2. A semi-skilled man is a man who, not having served an apprenticeship to the trade in which he is employed, has acquired some skill in some portion or portions of the work which would otherwise be performed by a skilled man. He is only capable of exercising such skill as he may possess under certain conditions.

3. An unskilled man is one who performs any operation not requiring manual dexterity of any kind.

4. Both semi-skilled and unskilled men may have a special knowledge which is of importance in the particular work they are employed on, but such knowledge cannot in any way amount to skill.

I am, Sir, your obedient servant,
R. D.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN—MERSEY SIDE BRANCH.—At the Liverpool University on Thursday, the 21st ult., under the auspices of the Engineering and Shipbuilding Draughtsmen's Association, a most interesting paper was read by Mr. D. S. Macbeth, A.M.I.N.A., on "Technical Education in its Relation to Draughtsmen." The chair was taken by Mr. Douglas Spencer, vice-president of the Merseyside Branch, and there was an excellent attendance of members and friends. Mr. Macbeth dealt with the subject from three points of view, viz., the draughtsman's work; his training for that work; and his prospects. He opened with a brief survey of the varied problems with which the draughtsman has to contend, showing the need of a scientifically-trained mind. He laid particular stress upon the fact that brains are not the prerogative of any one section of the community, that too many boys were taken into drawing offices who should be pushing hand-carts, whilst, conversely, there were many pushing hand-carts who, with opportunity of mechanical training, would have developed into brilliant technicists, enriching the world of engineering through their trained intellects. The lecturer insisted that admission to the drawing office should in all cases be by examination, as was now done by several firms, thereby ensuring that none but those having a natural inclination for the work would be accepted. Comment was made on the interest which some firms were now taking in the education of their apprentices, and instance was made of the excellent system of Messrs. Cammell Laird and Co., who recognised the efforts of their apprentices by granting weekly bonuses, awarding special prizes, and refunding their student fees. Mention was also made of the desirability of firms providing a library of technical books for the use of their employees in the pursuance of their technical studies. During the ensuing discussion opinion was expressed as to the desirability of the adoption throughout the country of a uniform test for candidates of the drawing office, and it was thought that the Draughtsmen's Association might determine this standard.

SOCIETY OF GLASS TECHNOLOGY.

THE February meeting of the above-named society was held in the University of Sheffield on Wednesday, the 20th ult., when the president (Mr. Frank Wood, B.Sc., F.I.C.) occupied the chair. A paper was read by Mr. H. H. Pitt, entitled, "*Some Notes on American Practice in the Glass Industry.*" Mr. Pitt has a considerable knowledge of the working of English, Continental and American glass houses, and the subject-matter of his paper dealt largely with information accumulated during a recent visit to the United States.

The American method of producing cut-glass ware in moulds was described first of all, and several articles were exhibited. The interior of each article is fine-polished by jets of flame under pressure, the outside being kept cool either by leaving in the mould or by removing and subjecting to an air blast. In all works in the States great care is exercised in keeping presses and moulds in first-class condition, and much of the success achieved must be attributed to this. Neglect of presses and moulds in many English factories leads to dire results. In American glass works the men work under ideal cooling condition and the comfort of the worker before the furnace is ensured by very large air-cooling devices. The lantern slides depicted the interior of several American glass houses, were most instructive. In some factories, systems of intermittent working are in vogue, the men having rest periods between spells of work. This is said to increase output and at the same time render the work less irksome.

Detailed descriptions were given of various types of pressing and blowing machines and good lantern slides were also shown. The Owens' bottle-making machines received very full treatment, and the whole of the works practice, from the mixing of the batch to the packing of the finished bottle, was described in detail. The arrangement of a factory using the Westlake bulb-blowing machine was also fully described, and the fact was pointed out that this machine worked from a special pot into which metal was ladled from the actual melting pots.

Not the least interesting portion of the lecture was a description illustrated by slides of the various methods of making sheet glass by machinery. The next meeting of the society will be held on March 20, at Newcastle.

THE BRACEBRIDGE HALL CLUB.—The directors of Messrs. William Foster and Co., Limited, Wellington Foundry, Lincoln, and the Committee of the Bracebridge Hall Club announce that the opening of the club is to take place to-morrow, the 2nd inst., by General Sir William Robertson. The club, as a first instalment, is to house 68 residential members. The building contains ample bedroom, residential and restaurant accommodation, and billiard, music, reading, writing and card rooms. The members' first access is to a heated locker room, where their working clothes may be exchanged, and to ample lavatory and bathing facilities.

COPPER MINING IN KOREA.—H.M. Consul-General at Söul writes that there has been a considerable development in copper mining operations at Kapsan, the firm owning the mines having already spent more than 100,000*l.* upon them. The export of crude copper from the mines was begun early in January, 1917, and by November 20 last 1,960 tons of crude copper, valued at 265,000*l.*, had been despatched to Japan. The Kapsan mines were purchased by a Japanese company from United Kingdom owners in 1916 at a cost of 3,000,000 yen. Minerals taken from the mines are roughly refined at the company's refinery on the spot. The quantity of crude copper obtained averages 250 tons a month, valued at about 340,000 yen. This output will gradually increase, and in the near future will reach 300 tons a month. The crude copper obtained is sent to Songjin and shipped thence to Saganoseki, Japan.

THE JAPANESE MERCANTILE FLEET.—According to *The London and China Telegraph*, it is announced that the Toyo Kisen Kaisha has decided to build 12 cargo ships during the next five years. They will cost approximately 50,000,000 yen. Arrangements are now being made so that most of the ships will be built at the Asano Shipbuilding Company at Tsurumi. Both the Uraga Dock Company and the Kawasaki Dock Company will be requested to assist in this big shipbuilding programme. As soon as the ships are completed the Toyo Kisen Kaisha will open another freight service to South America to which some of the Toyo Kisen Kaisha ships are already sailing in regular service. It is also proposed by this firm to open a regular line to India, owing to the growing trade relations between India and Japan. Regarding the money required to build these ships, the company, which has built several new ships and sold them to other firms, has 8,000,000 yen in cash set aside for the construction, not to mention the surplus available from the recent increase of capital to 35,000,000 yen. In addition to these 12 cargo ships, the Toyo Kisen Kaisha also contemplates the construction of several more fine passenger liners, including two which should be larger than any now on the transpacific service. Mr. S. Asano, president of the firm, who foresees a revolution with regard to the transpacific service, believes that the passenger and freight traffic will be divided into two different managements as on the Atlantic. Much material for the construction of these ocean greyhounds for the Pacific has been gathered already. In connection with this, another important announcement has been made indicating an ambitious plan of Mr. Asano. Assisted financially by Mr Yasuda, president of the Yasuda Bank of Tokyo, and several others, Mr. Asano now plans to build a steel mill near Tsurumi. The capital of the concern is fixed at 6,000,000 yen.

TRACTION ON BAD ROADS OR LAND.

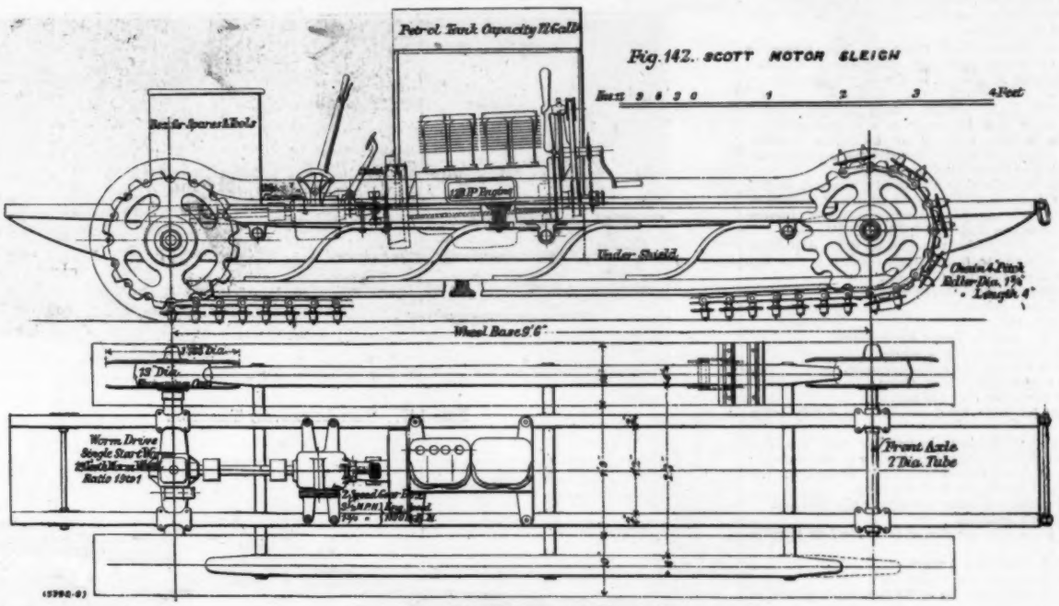


FIG. 142. THE WOLSELEY MOTOR SLEIGH.

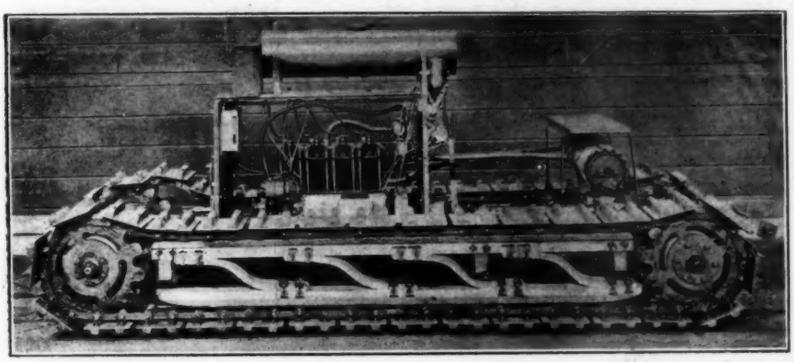


FIG. 145. THE WOLSELEY MOTOR SLEIGH.

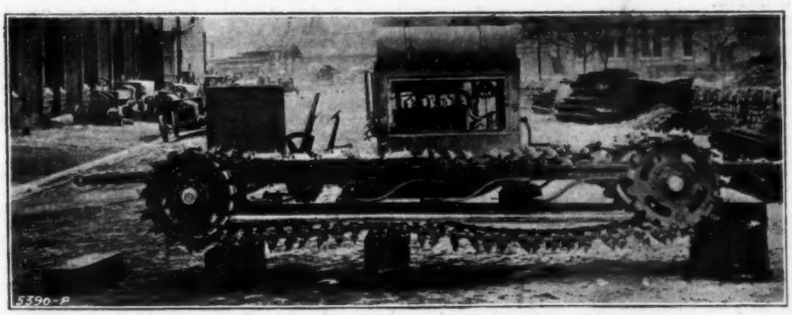


FIG. 140. THE WOLSELEY MOTOR SLEIGH.

TRACTION ON BAD ROADS OR LAND.*

By L. A. LEGROS, of Acton, Member.

(*Concluded from page* 214.)

The Wolseley Motor Sleigh.—This vehicle, Figs. 140, 142 and 145 on the present page, was designed and built for Captain Scott's Antarctic expedition in 1909; three of these motor sleighs were made with the object of facilitating transport over snow and ice.

A previous attempt was made by Mr. B. Hamilton to design a vehicle to cross hummocky ice and lumpy snow and ice, but on test in the Alps it was not found to meet the conditions sufficiently well. The Wolseley machine was designed to work with chain tracks and to form a motor sleigh. The first vehicle, which was completed in February, 1910, passed its tests satisfactorily on Lake Fefor in Norway. The vehicles were used by Captain Scott, and rendered much assistance in the earlier stages of the expedition, but were left behind in the final dash for the South Pole.

The vehicle is remarkable in the arrangement of bearers which take the load; these are of wood, shod with sheet aluminium to avoid "snow-clogging." The chains were of soft steel links with wooden rollers. It is to be noted that the arrangement adopted differs from any of the other tractors described, as the rollers travel with and at the same speed as the chain, and the rollers also form the gearing surface with which the driving and idler sprockets engage. The heads of the bolts that secured the links to the chain feet were made of pointed form, as shown in Fig. 142, so that the vehicle could travel equally well on smooth ice or over snow so loose that a man could only travel over it on skis. The engine was of 12 brake horse-power, air-cooled, transmitting its power through a two-speed box to a differential-box and axle at the back end. The front axle carried two idlers. The speeds provided were 1.75 m.p.h. on low gear and 3.5 m.p.h. on top gear. In the trials made at the works it was found possible to drive the machine over loose ashes without scattering them in any way. The motor sleigh was capable of climbing with ease a gradient of 1 in 2 (about 27 deg.).

Mixed Tractors.—By mixed tractors are meant tractors in which the traction can be effected wholly or in part by chain tracks, the load being carried on wheels; the only example of this class known to the author is the Lefebvre tractor.

The Lefebvre Tractor.—This vehicle, Fig. 147, page 240, is designed to travel on wheels when running over the ordinary road, the tracks being raised out of contact with the ground.

The tracks are of a construction quite different from any of the heavy-weight carrying tracks previously described. In this instance light steel case-hardened spade plates of L-section are attached to the pitch chains, each plate bridging six links of the chain. The spades present a vertical face to the ground, into which they cut when the chain is assisting the wheels. The aggregate surface so presented is that of seven plates on each track measuring about 4 in. by 6.5 in., giving a total area of about 360 sq. in., available for propulsion on soft ground on which the wheels would not grip. These chains on each track are carried on a frame, pivoted about the rear or driving sprocket, which is not concentric with the axle of the back wheels, but placed at some distance behind the axle. A jockey pulley carried on the track frame depresses the chain slightly in advance of the rear sprocket. Vertical guides with a power-operated screw gear enable the track frames to be depressed or raised through the full range in 15 seconds under control of the driver. The adherence chains are so geared as to travel at the same linear speed as the

* Paper read before the Institution of Mechanical Engineers on Friday, January 18, 1918. We regret that owing to the demands upon our space it is not possible for us to reproduce in ENGINEERING all the illustrations showing different types of tractors at work which accompany Mr. Legros's paper.

periphery of the driving wheels, but a dog-clutch carried on the sprocket shaft enables the chain drive to be disconnected when the chains are elevated and the tractor is running on hard ground.*

It is claimed that with the assistance of the adherence chains the tractive effort can be as much as 50 per cent. of the weight of the vehicle.

Applications of Chain-Track Traction.—The following are examples of work done by chain-track tractors where roads are poor or absent, and heavy loads require to be moved :—

Timber.—80,000 ft. of green rough timber hauled 15 miles over snow and ice track at a temperature of 40 deg. C.; the return journey of 15 miles without load, but with empty sleighs. Water tank and caboose for crew are included in the load both ways.

Clay and Gravel.—Hauling five to six wagons, loaded each with 6,000 lb. over heavy sand and over black land.

Ploughing virgin country; turning a 30-in. furrow 12 in. deep through scrub, Fig. 71, Plate XIV, *ante*.

Ploughing with five 14-in. ploughs to 8 in. depth, or with six 14-in. ploughs to 6 in. depth (45 h.p.).

Ploughing 40 acres per day (75 h.p.).

Ploughing partly drained marsh land.

Ploughing volcanic ash soil.

Ploughing a hill side.

Ploughing 16 in. deep in Texas Panhandle.

Ploughing 12 in. deep in black adobe.

Ploughing with a gang of 21 disc-ploughs.

Ploughing in sugar plantations, Cuba.

Ploughing 15 acres per day (35 h.p.).

Ploughing 100 in. wide by 7 in. deep in sandy loam (35 h.p.).

Rice farming; ploughing, harrowing and seeding. The chain tracks enable irrigation ditches to be crossed; the tractors also haul harvesters and binders in the harvest season and do the work of ditching.

Ditching; hauling a ditcher for laying tile ditches.

Road-making and grading.

Hauling materials through desert sand for Los Angeles Aqueduct.

Clearing land for Catskill Aqueduct.

Hauling rock, ore and road material.

Hauling load of 17 tons up a 20 per cent. grade in Utah (75 h.p.).

Hauling load of 40 tons of rock across country for highway construction in California (75 h.p.).

Hauling piledriver in marshy land.

Hauling house weighing 50 tons 1¼ miles in 45 minutes on dirt road (50 h.p.).

Hauling excavator.

Hauling scarifier.

Hauling sprayers.

Hauling harvester for 20-ft. cut.

Hauling 8-ft. double disc cultivator.

Hauling and operating hard-pan driller on fig plantation, California, for planting by dynamite.

For all the above operations it is estimated that the cost of haulage by tractor is from one-third to one-half of that by horse or mule.

In the instances quoted a few only of the appliances hauled or operated are designed specially for use with chain-track tractors.

Chain-Track Haulage Wagons.—Where heavy loads have to be carried over sandy and boggy country or through wide shallow fords with soft bottom, it is possible to extend the principle to haulage wagons fitted with chain tracks; by this means a 100-h.p. tractor can haul a train of four wagons, weighing 5 tons each, and carrying a load of 10 tons each, or a total dead load of 60 tons and a paying load of 40 tons, over soft ground capable of supporting only 7 lb. or 8 lb. per square inch.

A tractor hauling a train of chain-track wagons is shown in Fig. 149, annexed.

The Pedrail, fitted with an improved roller chain, Fig. 54, page 146 *ante*, arranged with two sets of rollers with axes at right angles to take vertical and horizontal loads respectively has been tried on a haulage wagon for stone (see Figs. 150 and 151, Plate XXII). The rolling friction is reduced by this arrangement to so small an amount that the vehicle will roll back on a 2 per cent. slope.

Other Applications of the Chain Track.—Trenching, ditching and farm drainage machines with chains of dredger buckets or excavating wheels are in many instances carried on and propelled by chain-track supports.†

Parsons Excavators.—The Parsons Company, of Newton, Iowa, make nine models of trench excavators; particulars of six of the larger models are given in Table II, pages 144 and 145 *ante*.

The model 60 Trench Excavator, Fig. 152, Plate XXII, is carried as to one-half of its weight on chain tracks, the other half being distributed over pairs of leading and trailing wheels. The machine is steam-driven, and comprises a conveyor for landing the spoil at an adequate distance from the trench.

The model 48 Trench Excavator is carried as to 75 per cent. of its weight on chain tracks, the remainder being carried on the leading wheels; the machine is driven by an internal-combustion motor of 62 h.p., and is illustrated in front view in Fig. 153, Plate XXII.

The model 24 Trench Excavator is of smaller size and fitted with a 30-h.p. motor; 71 per cent. of its weight is carried on the chain tracks and the remainder on the leading wheels. It is shown in back view in Fig. 154, Plate XXII.

Of the other models, one is entirely carried on chain tracks, the steering being effected by clutches as in the smaller models of chain-track tractors (Burford-Cleveland, &c.).

Austin Drainage Excavators.—The F. C. Austin Drainage Excavator Company are makers of seven models of trenching or ditching machines capable of digging trenches from 6 ft. to 25 ft. deep, and from 15 in. to 72 in. wide. The rate of digging is stated to vary from 10 ft. 3 in. per minute. The motors are from 18 h.p. to 85 h.p.; one of these machines is shown in Fig. 155, Plate XXIII. The spoil can be delivered either to the right or left or to both sides of the machine as may be desired.

Another series of four models is constructed by the Austin Company and arranged for performing the further operation of bank-sloping for the sides of the trench, either as a single operation or by roughing and finishing operations. The wheel of the excavator, over which the chain of buckets passes, is formed of two truncated cones, arranged base to base, the conical surface being represented by sloping cutter bars capable of cutting away hard adobe soil. The wheels are constructed for various slopes of bank from ½ to 1, to 1 to 1; the machines can be used for preliminary work in railroad construction, trenches being cut on each side of the land to be used, and the spoil from the two trenches conveyed to the middle of the strip where it is made up to formation level, berms of the desired width being left on each side between the ditch and formation as shown in Fig. 156, Plate XXIII.

Those ditching machines which are intended to perform consecutive operations of trenching and bank-sloping have the chain tracks arranged to straddle the trench; this necessitates great breadth of the machine, which will measure as much as 14 ft. 6 in. between the insides of the chain tracks for cutting a ditch 10 ft. wide at the top.

Applications of Trench Excavators.—These comprise: Cutting trenches for sewers, water mains, gas mains, electric light and power cables, as well as work for street railways and railroad construction.

Back Fillers.—The land dredgers having cut the ditches or trenches at high speed to the required depth, and the sewers or mains having been laid, it is necessary to fill in the spoil again. For this purpose a different class of machine is used, which is virtually a locomotive crane also carried on chain tracks. These machines are made by the constructors of trench-excavating machinery, and handle the spoil either with a clam-shell or grab bucket or with a drag-line bucket or a combination of the two for use alternatively. An example of a back filler is shown in Fig. 157, Plate XXIII.

Further extensions of the use of the chain track for carrying pile-driving machinery as well as that used for road-making and for deepening channels in shallow streams may be expected in the future.

Conclusions.—In conclusion it can be safely said that where a track can be found 7 ft. wide which does not present rocky obstacles over 10 in. high, whether over sand, ash, clay, marsh, snow or ice, on the level, or on gradients up to 30 per cent., the chain-track tractor has proved itself capable of travelling and performing useful work beyond the capacity of animal haulage.

For this reason the chain-track tractor may be expected to occupy a position of ever-increasing importance in the development of new countries, and in places where it is necessary to transport machinery and stores over roadless country many miles from the railway.

The difficulties presented by the working conditions are such that the author cannot regard any one of the existing systems as perfect, and expects that much will be done to improve the vehicles in the near future.

There is probably room for considerable improvement in the chain track itself as well as in its supports and its anti-friction devices. The variation in resistance to haulage is so great as between one system and another, not merely in static resistance to starting, but in dynamic resistance to haulage, that, as already suggested, the various track systems should form the subject of comparative tests at some of the great agricultural colleges.

One feature that is particularly remarkable is the small amount of power lost in compressing soft marshy land under the feet of the track chains. A very visible alteration of the appearance of a marshy surface due to the prints made by the track-feet may, for example, only involve an expenditure of power which is but slightly greater than that required for hard ground, whereas the effort involved in walking over the same soft surface may be many times greater than that of walking on the hard road.

The author desires, in conclusion, to express his thanks to Dr. W. H. Maw, past-president I.Mech.E.; to Mr. Coker F. Clarkson, general manager of the Society of Automobile Engineers; to the editor of *The Engineer*; to Colonel R. E. B. Crompton, C.B., R.E., Dr. H. S. Hele-Shaw, and Messrs. W. Defries, W. F. Rainforth, L. St. L. Pendred and G. W. Watson, MM.I.Mech.E., as well as to the engineers, representatives, and agents of the firms manufacturing the vehicles described, for information on a subject which is at the present time very deficient in literature, for valuable assistance, and for very many of the photographs and drawings from which the illustrations for the paper have been prepared.

APPENDIX I.

HISTORICAL NOTE.

The use of multiple-wheel traction for road tractors appears to have made its appearance in practical form almost simultaneously in France and Holland about

* A description of this tractor is given in ENGINEERING, vol. ci, pages 252 to 253.

† Since this paper was written a farm-drainage machine, with excavating wheel and chain tracks, constructed by the Pawling and Harnischfeger Company, of Milwaukee, Wis., has been described and illustrated in ENGINEERING, vol. civ, pages 228 and 237 and 238.

TRACTION ON BAD ROADS OR LAND.

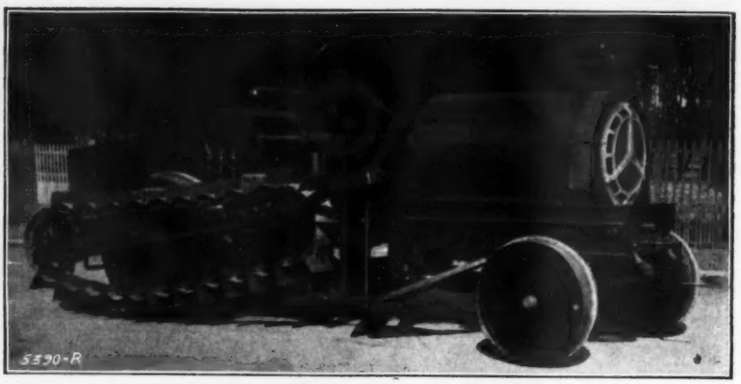


FIG. 147. THE LEFEBVRE TRACTOR.

FIG. 149. TRAIN OF CHAIN-TRACK HAULAGE WAGONS.

TRACTION ON BAD ROADS OR LAND.

Fig. 160. HEDGELAND AXLE

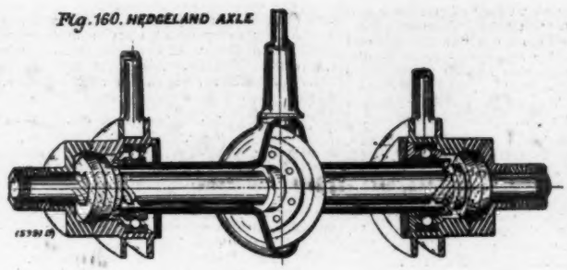


Fig. 161. FREE-WHEEL TYPE AXLE

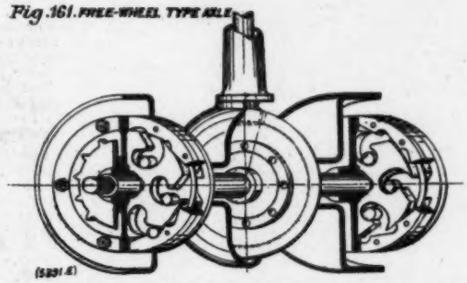


Fig. 162. CAM AND ROLLER-TYPE AXLE

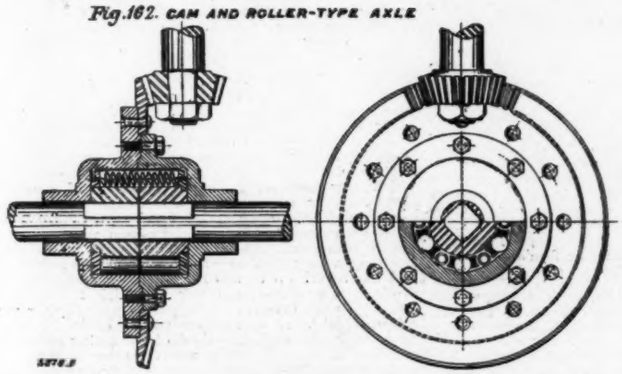
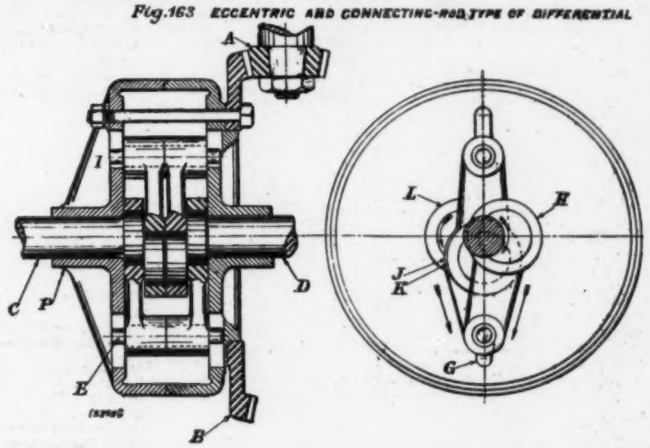


Fig. 163. ECCENTRIC AND CONNECTING-ROD TYPE OF DIFFERENTIAL



1903; in the latter country as the Spyker passenger car, and in the former as the Renard road train. The idea of the road train was taken up by the Daimler Company, of Coventry, in 1907, and trains on this principle, embodying considerable improvements on the original French design, were tested in India. Apart from trials on comparatively flat country near Bombay, other and very severe trials were made on the Gauhati-Shillong road at the instance of the Indian State Railway. This road, which is about 64 miles in total length, with about 7 miles level and a rise of nearly 5,000 ft. in the remainder accompanied by the sharp curves and steep pitches of an ordinary cart road, was subsequently worked on the block system with single vehicles. The abandonment of the Renard train does not, however, appear to have been due to any failure to meet the conditions of traction.

An illustration of the complete Renard road train is shown in Fig. 158, Plate XXIII, and the chassis are shown connected in plan in Fig. 159, on the same Plate.

The vehicles were connected for traction by a coupling-bar which ensured the steering of the trailing vehicles; the power was transmitted from the locomotor by a cardan shaft, with a sliding joint in the coupling section to permit of relative rise and fall of the vehicles.

There does not appear to have been either provision for compensating for varying velocities of the wheels of different vehicles, which could occur even with wheels of equal diameter on uneven surfaces, or provision of automatic locking devices for the differentials in case any driving wheel failed to grip. In such event the drive was taken by the other vehicles, but neither of the driving wheels of the vehicle in question could assist in traction under such circumstances.

It is worth noting that, in Young's work,* published in 1860, it is mentioned that a quarter-scale model made by Mr. Burstall of London, in 1827, and tested at Edinburgh, where it ran 250 miles in eight days, was arranged with a differential gear similar to that fitted to a steam coach by Rufus Porter, of Hartford, Conn., about 1830. The date of Burstall's model is therefore earlier than the date of Roberts's invention previously given by the author in a paper on the "Development of Road Locomotion in Recent Years,"† According to Young, the mitre-gear arrangement of differential also appears in the subsequent American carriage of James about 1834. From this it would seem that the idea of the application of the balanced differential gear to traction originated in Britain, but was first applied to full-size machines in the United States.

Difficulties with the bevel or spur forms of differential drive are familiar to all car drivers who have had experience with chain drives, particularly the difficulty caused by the fracture of a chain, which prevents driving except by the alternative of locking a sprocket and driving the other through the differential gear, with resultant doubling of the speed of the corresponding road wheel. To overcome this difficulty Hedgeland, of America, produced a solid axle with cone-clutches inside the wheel hubs, internally threaded, and carried on screwed portions of each end of the back axle, Fig. 160. The locking of one or other of these clutches with the corresponding wheel hub permitted driving; over-running of the wheel unscrewed the clutch and freed the wheel. The work was consequently all thrown on to the inner wheel, or, if the wheels were of unequal diameter, on the straight the larger wheel alone became the driver; furthermore, if the brakes were applied or other change made in the drive, causing engagement of either or both of the clutches, appreciable shock resulted. It will be seen that with the Hedgeland axle the car would be driven by either back wheel on the straight at a speed corresponding to the normal mean revolutions which would be obtained with the ordinary type of differential, but that on a curve it would be driven faster than the normal.

This class of differential is therefore not a true differential, in the sense that it does not divide the power; but it is an arrangement equivalent to free-wheeling either road wheel in advance of the propelling gear. Several forms of cam and roller (derivatives of the Bourdon clutch) or eccentric gears have been devised for the same object, all of which are merely mechanical variants of the free wheel. Fig. 161 shows this device applied to the hubs, and Fig. 162 shows it applied at the connection of the axle-halves.

Yet another form of differential is the eccentric and connecting-rod type, Fig. 163, in which each axle end is formed with two eccentrics with throws at right angles, and short connecting rods attached to these having gudgeon-pins common to each pair and sliding in slots in the differential casing. Thus in the illustration the short connecting rods L and H are attached to the pin E, the other pair J and K being attached to the pin I. It will be seen that the gear forms a balance gear the mechanical efficiency of which is reduced by friction in the eccentrics.

The subject has been dealt with very thoroughly under the title "Differential Substitutes" in a paper read by Mr. D. D. Ormsby, before the Society of Automobile Engineers (America), in June, 1916.* Mr. Ormsby points out that the trouble found with the ordinary differential is due to its being too efficient, and that it is possible to reduce the reversibility of the gear to any desired extent by using suitably-designed worm gears. The illustrations of worm differentials, Figs. 5 and 6, page 87 *ante*, show that the backlash in angular movement of the wheel may be much less than was the case with the Hedgeland axle.

It was claimed for the Hedgeland gear that a car fitted with it was less liable to side-slip; the same claim is made for the worm differential gear, but the advantage of the worm differential, which has secured its adoption in one or other of its forms on the majority of four-wheel driven cars intended for use on bad roads or land, is the elimination of difficulty with mud holes and ice patches.*

The earliest chain-track invention of which any record has been traced by the author is that of Richard Lovell Edgeworth of 1770.† In his description the inventor states that this "consists in making portable railways to wheel carriages, so that several pieces of wood are connected to the carriage, which it moves in regular succession in such manner that a sufficient length of railway is constantly at rest for the wheels to roll upon, and that when the wheels have nearly approached the extremity of this part of the railway their motion shall lay down a fresh length of rail in front, the weight of which in its descent shall assist in raising such part of the rail as the wheels have already passed over, and thus the pieces of wood which are taken up in the rear are in succession laid in the front, so as to furnish constantly a railway for the wheels to roll upon." If the word metal is substituted for wood, this description applies to the majority of the types of vehicles described in this paper.

The next step is the invention of Thos. German, in 1801, who placed a chain of rollers carried by linkwork between a runner, or sledge frame, carried on the vehicle, and the ground. This system, modified by the interposition of a chain track resting on the ground, also has its modern analogues, of which the Log-Hauler and Centiped are the more important. The idea was revived in slightly different form by Wm. Palmer in 1812, and subsequently by Richard Barry in 1821.

In 1825 Sir George Cayley proposed a revolving railway with "the several links or parts . . . connected to each other by joints so formed as to limit the angular movement of any two of the said links relatively with each other by a stop." The form of construction shown in this inventor's drawings closely resembles that adopted on some of the earlier modern attempts to

* "The Economy of Steam Power on Common Roads," page 351.

† Proceedings, I.Mech.E., 1910, page 1,555.

* Transactions of the Society of Automobile Engineers, vol. xi, 1916, Part II, pages 288 to 299.

The author is indebted to this paper for the illustrations of the Hedgeland free wheel, cam and roller clutch, eccentric and M and S worm differentials. Like Mr. Ormsby the author has not come across an example, in practice, of the eccentric and connecting-rod gear shown in Fig. 163.

* The makers of a model of four-wheel drive car quote the United States Government Specification No. 229 as being fulfilled by their gear, as follows:—

"Differential; the differential shall be of such a type as to automatically permit the wheels to revolve at different speeds without complete loss of torque on either wheel, and also to apply at least normal torque to whichever wheel shall have traction. These requirements shall be met when the vehicle is running either forward or backward."

† Since this paper was submitted to the Institution a series of articles on the "Evolution of the Chain-Track Tractor" has appeared in *The Engineer*, vol. cxxiv, pages 111 and 112, 134 to 136, 156 to 159, 181 to 184, 202 to 205, 221 to 224, and 241 to 244.

obtain a practical track-laying tractor; and, as has been shown, the chain proposed by him, with its limitation of angular movement, would have been subject to some of the disadvantages that retarded the recent development of this type of tractor in Britain.

The various attempts that were made to produce tractors in which the weight was distributed over a chain of rails or plates failed to evolve any practical device for nearly seventy years, when the less ambitious scheme, invented by Boydell in 1846, of a track-laying wheel, somewhat similar to the girdle wheels now in use for hauling heavy loads over soft land, was carried out in constructional form and actually subjected to severe tests on bad roads about 1858 to 1860. In this tractor the sections or feet were attached to the wheel by links.

Another system, making even less pretence to improvement in load distribution, was the Thomson loose rubber band creeping between the wheel centre and the track of tyre shoes. In the earliest form the shoes were designed as a continuous chain girdle and later consisted of independent shoes. Road locomotives so fitted were adopted for the traction of road trains on the Grand Trunk road in India under the direction of Colonel R. E. B. Crompton.* The system had an active life of several years in the early seventies. The engines weighed about 9 tons, and hauled some 16 tons of load without undue road wear. The expense of maintaining the rubber tyres under these conditions was as low as 1.5*d.* per mile run. The invention constituted the first practical attempt to reduce the unsprung weight of the vehicle to that of the tyre shoes alone.

In the latter half of the nineteenth century but few attempts to revive track-laying tractors appear to have been made. At the Royal Agricultural Society's show, held at Kilburn in August, 1879, two vehicles were exhibited by W. C. Pellat, of Clerkenwell.† These were fitted with self-laying continuous tracks of flat plates secured to chains; the jointing of the successive links was thus of the most primitive character with practically point contact between the chain links. The resultant wear would be sufficient to account for the failure of these vehicles to attain success although they again demonstrated the advantages of the chain track for transport over soft ground.

The combination of the two ideas of the chain track and the foot-spring in the same vehicle was developed by Diplock in his Pedrail alluded to by Dr. Hele-Shaw in a lecture given at Liverpool in 1903,‡ and in the discussion on road locomotion.§ The diagram given by him, Fig. 40, page 118, *ante*, illustrates a further stage in the attempts to improve the springing of track-laying vehicles, a feature considered of but little importance in the earlier forms, but one the value of which is now being appreciated to an increasing extent by the manufacturers of chain-track tractors.

APPENDIX II.

AUTHORITIES CONSULTED.

Young, C. F. T. "The Economy of Steam Power on Common Roads, London, 1860."
Proceedings of the Institution of Automobile Engineers.
Proceedings of the (American) Society of Automobile Engineers.
Proceedings of the Institution of Mechanical Engineers.
Engineering; *The Engineer*; *The Autocar*; *The Implement and Machinery Review.*

CATALOGUES.

Electric Enclosed Motors.—In many situations it is necessary that the motor be enclosed in a casing and a well-finished series of these is shown in a number of single-leaf catalogues received from the Enclosed Motor Company, Limited, Finsbury-court, Finsbury-pavement, London, E.C. 2. The casing with fixing lugs on base is in one piece, and the two circular dished ends are attached by four set screws in each.

Small Pumps.—The Fulflo Pump Company, 126, Opera-place, Cincinnati, U.S.A., send catalogues of small centrifugal pumps for machine tools. These are without valves, and the outlet is high, so that the pump retains priming. They are very compactly and neatly made in cast-iron, bronze and aluminium, in ¾ in., ¾ in. and 1 in. sizes. The firm is producing 500 pumps per day and arranging to double this output.

Electric Lamp Fittings.—A catalogue of fittings specially designed for half-watt lamps, including a number particularly adapted for offices and workshops, comes from Engineering and Arc Lamps, Limited, Sphere Works, St. Albans, Herts. Indoor indirect and semi-indirect, as well as outdoor, lighting are provided for. Some strong hexagonal lanterns are shown as alternatives to globes. These fittings are all made by the company at St. Albans.

Electric Lamp Carbons.—The General Electric Company, Limited, Witton, Birmingham, send a catalogue of carbon rods for arc lamps. These include cored and solid sticks for open-type lamps and enclosed type lamps; flame carbons with and without metal cores; and carbons specially for kinematograph work. The company also make special types of coppered, searchlight, electric-welding and battery carbons. Full particulars of application, measurements and prices are given.

Safety Glass.—The glass made by the Triplex Safety Glass Company, Limited, 1, Albemarle-street, London, W. 1, is now used for a great variety of purposes and made in three to eight-ply, with total thicknesses from three thirty-seconds of an inch to 3 in., the sizes of 1 in. and over being used for armoured-car look-outs. A bullet fired from a service rifle at 300 yards range does not go through the five-ply 1¼ in., and no splinters come from the cracking. The sheet is built of layers of glass with layers of transparent xylonite interposed.

Sawing Machines.—A catalogue from Messrs. W. A. Walber and Co., 38, Victoria-street, London, S.W. 1, describes a reciprocating sawing machine for heavy work. The drive is by fast and loose pulleys, the guides are of circular section, the saw is lifted from the work on the idle stroke, and tank and pump for cutting liquid are fitted. It is made in two sizes, for 17-in. and 30-in. blades. Cutting speed, 110 strokes per minute. The machine is designed to withstand wear and maintain accuracy.

Asbestos.—Messrs. Turner Brothers Asbestos Company, Limited, Rochdale, send the first number of a publication which they intend to issue quarterly. It contains an excellently-written article on the origin and properties of asbestos by Mr. H. W. Rowell; also several technical papers and a lot of news about the schools, scouts, allotments, choirs and various matters in which the firm and their employees are specially interested. Two rather fine illustrations show the main square of Arras "Before the Huns Arrived" and "The Penalty of War."

Electric Circuit Breakers.—The British Thomson-Houston Company, Limited, Rugby, send an illustrated and fully descriptive catalogue of automatic circuit breakers for alternating and continuous currents. These are designed to meet all the latest requirements for heavy service on power and lighting circuits up to 6,000 amperes continuous rating. All the details which make for safety, convenience and easy operation are carefully worked out and, as usual with this firm's catalogues, full lists, dimensions and weights are stated.

Machine Tools.—An interesting booklet comes from Messrs. A. A. Jones and Shipman, Limited, Leicester, describing their works and products with several very good illustrations. It is not really a "catalogue"; it is a specially-written greeting from the staff to their comrades with the colours. From this firm over 70 men are serving; of whom one has died of wounds in France, one of fever in India, and nine have been released or discharged. The letterpress is excellent; homely and friendly in tone, full of cheerful news about the works, and fired with robust patriotism. One of the best ideas of "literature for the front" we have seen.

Temperature Regulation.—Automatic regulation of temperature within very close limits is effected by an instrument made by Messrs. James Baldwin and Co., Keighley, Yorks. It is applicable to supplies of air, gas, steam or hot water, and is interposed in the supply pipe-line. In action it maintains full bore supply until the set temperature is reached and then cuts off, automatically reopening and closing as required to maintain the set temperature. A slight electric current is used to operate the valve and, in case of accidental failure of this current, the instrument can be made to maintain the valve open or shut (as safety may require) until the current is restored. It acts over a considerable range and up to 600 deg. F., and has been successfully used for a great variety of purposes.

Grinding Allowances.—A card showing the amount of extra metal to be left by the turner in order to allow for grinding, has been issued by Messrs. Alfred Herbert, Limited, engineers, Coventry. The amounts are easily found from coloured curves printed on squared paper, curves being shown for bar work and another set for internal grinding. Diameters (of work) from ¼ in. to 12 in. are set out, and there are different allowances for work over and under lengths of 12 diameters. The least allowance is 0.005 in. on ¼ in. diameter bars, under 6 in. long and smooth turned. The largest allowance is ¼ in. on 12-in. diameter bars over 12 ft. long and rough turned. Rough-turning is recommended generally for economy. Work which is to be case-hardened before grinding must, of course, be turned smooth. A copy of the chart will be sent post free to any one applying to the firm.

Aircraft Supplies.—The Aircraft Supplies Company, Limited, 125, Long Acre, London, W.C. 2, send a useful wall card giving the approximate total lengths and weights of hexagon bar required to make 50 gross of each diameter and length of A.G.S. bolts. This table gives the A.G.S. alphabetical marks for length of bolts. A = 0.2 in. long, B = 0.4 in. long, and so on by fifths of an inch to O = 3 in. long; then P = 3.25 in. long, Q = 3.5 in. long, and so on by quarter inches to W = 5 in. long, X = 5.5 in. long, and Y = 6 in. The company calls our attention to an error in our paragraphs in vol. civ, page 702, in which we gave "E = 2 in. long," which should have been E = 1 in. long. This firm also prints a chart with illustrations and dimensions of A.G.S. standard eyebolts, studs, bolts, &c. These tables are useful safeguards in regard to a system which is somewhat confusing.

Electric Circuit Breakers.—A catalogue of oil-break circuit breakers which comes from Messrs. George Ellison, Birmingham, is quite a model compilation, in giving full, frank and well-arranged technical information and particulars of every useful detail, including prices. These breakers are for maximum supply pressure of 750 volts and for alternating or continuous current. There are three main sizes, each built in two, three and four-pole patterns. Careful attention has been given to the different methods of connecting cables and the breaking capacities of the switches, based on actual tests, are stated definitely. The breakers are supplied for controlling independent circuits and motors, and also mounted in line with bus-bars and accessories to form main switchboards. All parts are standardised and interchangeable, and extras and accessories are also listed.

Small Drilling Machines.—The Langelier Manufacturing Company, Arlington, Cranston, R.I., U.S.A., send a catalogue of small drilling and tapping machines for drills up to eleven thirty-seconds of an inch diameter. The machines are designed in a great variety of forms for belt or motor drive, with single or several speeds, for bench or pedestal fixing, with one, two or three-drill spindles, and in some cases with tank, filter and pump for cutting liquid. The bearings are of the plain type, with phosphor-bronze for high speeds. The variety makes it possible to select machines suitable for the work. There is also a special range of machines for precision work. The catalogue gives full details of each machine, with illustrations. The details of adjustments, belt shifting, &c., are carefully designed, and the main castings neat and strong. A useful horizontal machine is also shown for tapping, with open and cross-belt drive. It may be fixed on a bench, and is made with single head or with a tailstock.

Vertical Steam Engines.—Where factory floor space is limited the vertical engine is preferred, which means that in this country it is very often preferred in textile, paper and flour mills, in pumping and refrigerating. Messrs. Cole, Marchent and Morley, Limited, Bradford, have fitted many of their engines of this type, and show photographs of them in position in a special catalogue which they send us. The list of engines of standard make includes 16 compound and 16 triple expansion, in various forms, ranging from 335 i.h.p. to 3,520 i.h.p. These are normal continuous-load powers which may be pushed to a maximum of fully 20 per cent. more. The compounds are suitable for steam pressure up to 160 lb. and the triples up to 200 lb. All are fitted with the firm's patent drop-piston valves, which fall at full velocity to the cut-off and then slow gradually for the return stroke. A special compound engine is also made with a patented method of extracting steam at constant pressure from the receiver after it has done work in the high-pressure cylinder—a system favoured in mills where a large amount of steam is used for heating, drying and other processes.

JAPANESE SHIPBUILDING.—According to *The Marine Journal*, New York, for January 26, the Japanese shipbuilding programme for 1918 contemplated the launching of 9 steamers in January, 5 in February, 11 in March, 6 in April, 7 in May, 1 in June, 4 in July, 8 in August, 5 in September, 4 in October, 1 in November, and 5 in December, making a total of 66, having an aggregate tonnage of about 130,000 tons gross.

MOLYBDENITE IN THE PROVINCE OF QUEBEC.—The Province of Quebec may boast of possessing the largest and most important molybdenite mine in the world. It is situated at Quyon, 30 miles from Ottawa, on the north shore of the Ottawa River. This occurrence has been known for a long time, but comparatively little interest has been taken in it until the keen demand for molybdenite stimulated prospecting and development. Work was begun on the Quyon molybdenite deposit, now the Moss mine, in March, 1916, and a few weeks later a carload of high-grade molybdenite ore was shipped to Denver, Colorado, for concentration in the plant of the H. E. Wood Company. Shipment of ore to various concentrators were continued regularly after that, until the completion of a mill at the mine, and towards the end of 1916 only concentrates were shipped from Quyon. The recovery of pure molybdenite from the ore mined at the Moss mine from March to December, 1916, amounted to very nearly 30 tons. Early in 1917 the mine, which had been worked by the Wood Molybdenite Company, was acquired by a powerful American syndicate, the Dominion Molybdenite Company, who spent several months in diamond drilling to block out reserves of ore and in improving the method of concentration. Results have been most satisfactory. They have now ore for several years in advance, and the extraction of molybdenite from the ore is now over 98 per cent. of the contents. The principle of concentration adopted is selective separation by Callow cells. Although actual mining and milling were retarded by the development and the experimental work, the production for 1917 considerably exceeds that of the previous year, and at the present moment the mill is treating 150 tons of ore per day. The concentrates are all converted into ferro-molybdenum in electric furnaces at Belleville and Orillia in Ontario. Another molybdenite deposit has come to the fore in the Province of Quebec in 1917. It is situated in Huddersfield township, 40 miles north of Quyon. It is worked by the Wood Molybdenite Company, who have put up a small concentrator, to treat 20 tons a day. Although this deposit does not appear to be as extensive as the one at the Moss mine, it is rich, and bids fair to be very remunerative. Molybdenite occurrences are numerous in the large expanse of Archean rocks, which occupy 90 per cent. of the Province of Quebec, and the annual report of the Bureau of Mines of the Province of Quebec for 1916 gives a list of the principal ones on which prospecting and development work has been effected.

* Proceedings, I.Mech.E., 1879, page 530.
† *The Engineer*, vol. xlvii, page 124.
‡ "The Pedrail," a Revolution in Mechanical Locomotion. Lecture delivered to the Liverpool Self-propelled Traffic Association, by Professor H. S. Hele-Shaw, at Liverpool University, November 28, 1903.
§ Proceedings, I.Mech.E., 1910, pages 1,561 to 1,566.